3.4 Streams, Wetlands, and Subsurface and Groundwater Conditions, and Surface Water Management

This section describes the affected environment, analyzes potential impacts, and provides recommended mitigation measures related to streams, wetlands, and surface water management.

Content from the addendum to the 145th Street Station Subarea Plan/Planned Action DEIS, published February 19, 2016, also is included. The addendum was prepared in response to comments received during the DEIS comment period pertaining to wetlands, streams, wildlife habitat, water quality, groundwater conditions, subsurface soils, and other related topics. Subsequent to publishing the DEIS and the close of the public comment period for the DEIS, the City of Shoreline decided to undertake additional analysis of the two natural systems in the subarea known to contain large critical areas: Paramount Open Space and Twin Ponds Park. The addendum included two technical memorandums that were published and discussed with the Planning Commission on February 18, 2016: a Wetlands and Streams Assessment and Geotechnical Considerations for High Groundwater or Peat Conditions. Although not required, a public comment period was offered through March 21, 2016 on the DEIS addendum. Responses to comments received on the addendum and the DEIS are provided in Chapter 4 of this FEIS.
For additional information and analysis specifically related to parks, recreation, open space, natural areas, and priority habitat areas, refer to Section 3.5 of this FEIS.

3.4.1 Affected Environment

Drainage Basins and Subbasins

Hydrology, including natural and constructed systems within the City of Shoreline, can be divided into seven major basins. The subarea (and the study area for this FEIS) is located primarily within the Thornton Creek Basin. Four subbasins exist across the subarea within the Thornton Creek Basin:

- Meridian Creek
- Twin Ponds
- Upper Littles Creek
- Hamlin Creek

A small portion of the subarea, approximately 1.45 acres, is located in the Boeing Creek Basin along 155th Street.

Maps shown in **Figure 3.4-1** and **Figure 3.4-2** depict the Thornton Creek Basin and subbasins listed above in the subarea and vicinity. These maps are from the Thornton Creek and West Lake Washington Basin Characterization Report, prepared by Tetra Tech for the City of Shoreline in May 2004.

Thornton Creek Basin

The Thornton Creek Basin, which also extends into the City of Seattle to the south, is the largest basin within the City of Shoreline and drains approximately 2,304 acres in the southeast quarter of the city. South of Shoreline, Thornton Creek meanders roughly five miles through northeastern Seattle before discharging to Lake Washington.

The basin within City of Shoreline is almost completely developed, with primary land uses being single-family residences and roads. Commercial areas are the next most prevalent land use type, followed by institutional uses. Currently, there is a relatively small amount of multifamily use or apartments. Since Interstate 5 (I-5) bisects this basin, it and the resulting connector streets and on/off ramps contribute a large volume of impervious surface runoff to the basin.

The Thornton Creek basin drainage system within the City of Shoreline consists primarily of piped and channeled surface water conveyance. Many of the historical Thornton Creek basin watercourses and associated wetlands and floodplains were removed by development, typically during the 1950s and 1960s. The hydrologic benefits offered by these natural features, including aquatic habitat, water quality enhancement, and infiltration and storage of peak flows, have been greatly diminished. A few natural infiltration or detention features remain within this basin to mitigate peak runoff flows, including several streams, Twin Ponds and associated wetlands, and wetlands in the vicinity of Paramount Open Space.

Prior to the more recent implementation of regulations to mitigate the runoff impacts of development, urbanization within the Thornton Creek basin increased the peak flows of the stream, resulting in intensified erosion and sedimentation in the system. Development practices contributing to watershed degradation over decades have included building homes without adequate drainage systems, filling in drainage ways, and construction without sufficient erosion control measures. Much of the existing development and infrastructure in the basin was built prior to adoption of surface water management regulations, and particularly the more stringent regulations that are in place today to protect system flows, water quality, and habitat.

Of the four subbasins in the vicinity of the 145th Street Station Subarea, the most land area drains to the Twin Ponds Subbasin and the Littles Creek Subbasin. The west portion of the subarea is within the Meridian Creek Subbasin, while a small portion of the eastern edge is within the Hamlin Creek Subbasin.

The Twin Ponds Subbasin (461 acres) is downstream of the Ronald Bog Subbasin along the North Branch of Thornton Creek. South of Ronald Bog, Thornton Creek is mostly open channel with three long sections of piped conveyance. The first section of piped conveyance is directly south of Ronald Bog and the second passes beneath the King County Metro Bus Facility. The third section occurs when Thornton Creek flows into the Washington Department of Transportation (WSDOT)-owned piped conveyance system approximately 1,100 feet north of the city limits, crossing under Interstate 5 (I-5) into the City of Seattle at the Jackson Park Golf Course.

Littles Creek flows southward, roughly parallel to and approximately one half mile east of I-5. The Littles Creek-Thornton Creek confluence is located within the City of Seattle near 15th Avenue NE and NE 130th Place. This subbasin (466 acres) collects drainage from mostly residential areas. The tributary originates at a small detention pond located at the southwest corner of 170th Street NE and 15th Avenue NE. The stream then flows southward for about one mile within a piped or channelized conveyance system (including 800 feet of private property backyard channel between NE 158th Street and NE 155th Street) to the Paramount Open Space and its wetland system.

The Meridian Creek Subbasin is approximately 350 acres with a piped conveyance system running southward along Wallingford Avenue N. West of Meridian Avenue N, Meridian Creek briefly enters an open channel system, flowing eastward into the south pond at Twin Ponds Park and joining the Thornton Creek North Branch.

The Hamlin Creek Subbasin totals about 348 acres and includes the mostly forested Hamlin and South Woods Parks, a large centralized grouping of campuses consisting of the State-owned Fircrest site, Shorecrest High School, and Kellogg Middle School, and the surrounding residential neighborhoods. Within the City of Shoreline, Hamlin Creek is typically confined to a piped system and has intermittent flow. The Hamlin Creek confluence with Thornton Creek is within the City of Seattle.

Boeing Creek Basin

The Boeing Creek Basin is the largest drainage basin in Shoreline, with approximately 1,740 acres contained entirely within the City of Shoreline. The majority of the Boeing Creek open channel watercourse is contained within a forested ravine that has fairly good riparian conditions through Boeing Creek and Shoreview Parks and through the private Boeing Creek Reserve within the Innis Arden development. Land use is predominantly low-density residential, but includes a few large campus sites and a high-density commercial corridor along Aurora Avenue N from N 145th Street to approximately N 183rd Street. Per the recent Boeing Creek Basin Plan, the basin is approximately 67 percent impervious surfaces and 90 percent developed.

The study area for Alternative 2—Connecting Corridors extends approximately one block into the Boeing Creek basin, along N 155th Street, with zoning revisions proposed to several parcels covering approximately 1.45 acres. There is limited measurable impact anticipated to the natural environment and stormwater management systems within the Boeing Creek Basin due to the small size of the area with proposed changes in zoning. Approximately half of the area is currently zoned Mixed Business, R-24, and R-12. The other half is zoned as R-6. Only Alternative 2—Connecting Corridors proposes zoning revision to this area to Mixed Use Residential (MUR)-45. Due to the relatively insignificant size of this area within the Boeing Creek Basin (less than 0.1 percent of the total basin), it was not a major focus of the FEIS analysis.

Wetlands and Streams

General Wetland and Stream Conditions in the Subarea

Streams in the Thornton Creek Drainage Basin include reaches of Thornton Creek, Meridian Creek, drainages in the vicinity of Twin Ponds, the Littles Creek system, and portions of the Hamlin Creek system. The Twin Ponds area streams and Littles Creek system are the predominant streams in the subarea.

There are ten classified wetland areas within the Thornton Creek watershed in the City of Shoreline. Many of these exist within the subarea, including two within Twin Ponds Park and two within Paramount Open Space.

These wetland and stream systems extend onto both public and private property.

DEIS Addendum - Additional Assessment of Paramount Open Space and Twin Ponds Park Areas

Biologists conducted stream and wetland reconnaissance focused on public properties, including assessments at Paramount Open Space and Twin Ponds Park within the 145th Street Station Subarea on August 25 and September 1, 2015. The purpose of this wetland and stream reconnaissance and assessment was to evaluate the opportunities and the limitations of development due to these critical areas and their buffers, as well as to address the potential resulting effects on ecosystems in the subarea. In performing this assessment, biologists 1) determined the general extent of wetlands and streams in City-owned areas of the subarea that may see zoning changes, 2) conducted a preliminarily determination of the classification of any wetlands and/or streams occurring on City-owned properties, and 3) performed a preliminarily establishment of wetland and/or stream buffers and considered whether buffers may extend on to other parcels.

It should be noted that this reconnaissance and assessment level of analysis was *not* a full delineation of wetland and stream boundaries and characteristics, but rather a high level analysis supported by field observations. This level of analysis was sufficient to inform the FEIS study, with the understanding that future redevelopment applications would be required to fully delineate streams and wetlands as part of their proposals, and those future delineations would provide the most up-to-date, accurate level of detail at that time. These delineations are required within planned action subareas, as well as all other areas, for both public and private properties, in all zoning designations.

Because stream and wetland systems are dynamic, and their characteristics change over time, performing this general reconnaissance and assessment provides a preliminary understanding of existing conditions at this time. Future delineations and surveying of wetlands, streams, and buffers associated with specific development proposals (under any of the alternatives) will provide the most up-to-date and accurate descriptions and mapping of these areas, and as such will be the binding conditions related to future site-specific permitting.

Methodology

Biologists used the methodology derived from the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual:*

Western Mountains, Valleys, and Coast Region (USACE 2010) and the *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory 1987). This method prescribes an assessment of vegetation, soils, and hydrology related to the streams and wetlands. As stated above, ***work was conducted only on the City-owned parcels identified above; no work was performed on privately-held parcels.*** The timing of the assessment in late August/early September is typically a drier time of year. However, assessments and delineations of streams and wetlands are conducted year-round, and delineations are required to define boundaries and characteristics accurately across all seasons of the year. Delineations are often completed during the growing season, when vegetation is at its peak and can be readily identified.

Data on vegetation, soils, and hydrology were collected in areas that appeared to have wetland characteristics. Data on soils, hydrology, and vegetation were collected for a number of wetland and upland plots, in order to characterize wetlands and to confirm wetland presence and the physical extent of wetland boundaries. Information on wetland edge location was recorded using a Trimble GeoXH 6000, a resource-grade GPS unit with sub-meter accuracy. Wetland flags were not deployed at wetland edges for this work, nor were wetland edges surveyed. Sizes of wetlands were estimated based on the GPS points taken. Wetlands were rated as required by the Shoreline Municipal Code (SMC) 20.80.320.B using the *Washington State Wetland Rating System for Western Washington 2014 Update* (Ecology Publication No. 014-06-029). Wetland buffer widths were determined based on wetland rating category per SMC 20.80.330.

Stream systems were qualitatively assessed for in-stream habitat units, substrate, large wood, riparian habitat, and potential fish presence/fish habitat. Full stream habitat surveys and/or fish surveys were not conducted for this work. Ordinary High Water was located using the Trimble GEOXH 6000 GPS unit. Streams were typed per SMC 20.80.270.B(5), and buffers were established based on stream type and presence of fish habitat per SMC 20.80.280.

Relationship to Earlier Studies

The wetland assessment completed in 2015 was an independent effort from previous earlier analyses prepared by others, such as the 2004 Tetratech Thornton Creek Basin Characterization Report and the 2009 Thornton Creek Watershed Plan. While these documents were referenced as part of the assessment work, the 2015 work was more limited in geographic extent than the earlier analyses. While the 2015 assessment involved taking an up-to-date look at publicly-owned land areas in the vicinity of Paramount Open Space and Twin Ponds Park, it was a high-level reconnaissance and not a delineation and survey of wetlands and streams in those areas. The 2015 assessment was not as extensive and detailed as the earlier studies, which are still regularly referenced by the City of Shoreline as part of ongoing basin planning and stormwater management.

Wetlands and Streams Mapping

The map shown in **Figure 3.4-3** depicts stream reaches, wetlands, and fish passage barriers in the Thornton Creek Basin from the Thornton Creek and West Lake Washington Basin Characterization Report, prepared by Tetra Tech for the City of Shoreline in May 2004.

Figure 3.4-4 and **Figure 3.4-5** show preliminary mapping of streams, wetlands, and potential associated buffers in the vicinity of publicly-owned lands in the vicinities of Paramount Open Space and Twin Ponds Park from the 2015 wetland assessment. The Paramount Open Space area is shown in **Figure 3.4-4** and the Twin Ponds Park area is shown in **Figure 3.4-5**.

Mapping of wetland and stream elements in the 2015 reconnaissance/assessment was based on a planning-level GIS methodology and not on field delineation and survey. As such, the mapping is approximate and preliminary. Future wetland and stream delineations would need to be completed, mapped, and surveyed prior to any site redevelopment in the future to accurately confirm wetland, stream, and buffer limits. Given that wetlands and streams change over time, the most prudent approach for the DEIS Addendum was to conduct a reconnaissance level assessment, with the understanding that property owners and/or developers would be required to conduct their own detailed wetland and stream delineations as part of the permitting process for future redevelopment plans. (This would be required under any of the alternatives, including Alternative 1—No Action or any of the three action alternatives that may be adopted.)

The City of Shoreline requires that property owners and developers confirm and provide technical documentation of critical areas conditions on their properties when submitting applications for site development and building permits. In addition to City of Shoreline Critical Areas Requirements, which are applicable under Shoreline Municipal Code 20.80 Critical Areas, future project applications would be subject to federal and state regulations that apply to redevelopment of sites with streams and wetlands or in proximity to streams and wetlands.

Figure 3.4-6 shows riparian characteristics along several of the streams in the basin, as identified, analyzed, and mapped in the Thornton Creek and West Lake Washington Watershed Basin Characterization Report, 2004.

Since hydrologic systems in the watershed are dynamic and change over time, it is again important to note that mapping depicted in this FEIS and in other earlier reports can be subject to change and as such should be considered preliminary. Site-specific analysis at the time of proposed development will take precedence.

City of Shoreline Critical Areas Map

Figure 3.4-7 is the Critical Areas Map referenced by the City of Shoreline as part of project permitting. If the sites proposed for development or redevelopment have the potential to contain critical areas based on a review of this map and conditions observed in the field, project proponents are required to prepare a critical areas report to address these conditions and comply with the requirements of Shoreline Municipal Code, Chapter 20.80, as well as other applicable city, state, and federal regulations. The required reporting would include delineations and surveys of streams, wetlands, and buffers as previously discussed.

2015 Assessment Results for Wetlands

Several wetlands and stream systems were identified on the City-owned parcels. Seven wetlands were identified in the Paramount Open Space area and two were identified in Twin Ponds Park. Seven stream reaches were also identified on the City-owned parcels—five on the Paramount Open Space parcels and two on the Twin Ponds parcels. A number of privately held properties are within the buffers for the wetlands and streams on both the Paramount Open Space and Twin Ponds Park areas.

Table 3.4-1 lists the wetlands, wetland classification, size, and buffers for the project wetlands. Information on hydrology, soils, vegetation, and wetland classification and wetland buffers follows, based on the City of Shoreline Critical Areas Ordinance, SMC 20.80 (last updated December 2015).

Hydrology Characteristics

The Paramount Open Space wetlands and the Twin Ponds Park wetlands display hydrologic regimes that are largely supported by groundwater, although stream systems are associated with the wetlands and are in close proximity to them. Most of the wetlands are depressional, and water in the various wetlands may pond either permanently or seasonally. Portions of Wetland I (see **Table 3.4-1**), associated with Twin Ponds Park, are permanently ponded and have an open water component. The slope and riverine wetlands displayed evidence of either groundwater expression (Wetland H), and/or of ponding and/or overbank inundation (Wetland J).

All of the wetlands showed high groundwater levels during the reconnaissance work, and soils were saturated to the surface. This is particularly noteworthy given that the assessment work was done in the summer of 2015, which experienced unusually dry conditions. Many areas of the wetlands showed surface water at depths ranging from less than one inch to several feet in the Twin Ponds Parks wetlands. All wetlands in the Paramount Open Space and Twin Ponds Park areas showed one or more primary wetland hydrology indicators, thus meeting the criterion for wetland hydrology.

Soils Characteristics

Soils in the Paramount Open Space and the Twin Ponds Park wetlands display dark soils, with low values (typically values of 2, occasionally 3), and low chroma (typically 1, occasionally 2). All sampled wetland soils had distinct hydrogen sulfide odors, and many of the soils had organic components such as decaying vegetative detritus. Although loamy soils were the dominant wetland soil type, significant components of clay and silt were often present as well. All wetlands in the Paramount Open Space and Twin Ponds Park areas showed one or more primary wetland hydric soil indicators, thus meeting the criterion for wetland soils.

Soils in both the Paramount Open Space and the Twin Ponds Park are generally derived from Vashon till. Dominant parent soils are mostly Everett gravelly loam soils, although Twin Pond Parks contains peat soils as well (TetraTech/KCM, 2004).

Vegetation Characteristics

Wetland plant communities at the Paramount Open Space and the Twin Ponds Park sites were mainly forested communities, with some emergent and scrub/shrub communities either interspersed within the wetland matrix or occurring beneath the forested canopy.

Typically, red alder (*Alnus rubra*) was the dominant tree species in the forested wetland communities, with species such as black cottonwood (*Populus trichocarpa*) and western red cedar (*Thuja plicata*) occurring occasionally in and along the edges of the wetlands.

Salmonberry (*Rubus spectabilis*) was the dominant shrub species, although willow species (*Salix* spp) occurred in small patches and/or locally dense thickets. Other less common wetland shrub species included red osier dogwood (*Cornus sericea*) and beaked hazelnut (*Corylus cornuta*).

Common herbaceous wetland species at both the Paramount and Twin Ponds sites included creeping buttercup (*Ranunculus repens*), lady fern (*Athyrium filix-feminina*), horsetail (*Equisetum* spp), false lily-of-the-valley (*Maianthemum dilatatum*), western skunk cabbage (*Lysichiton americanus*), and invasive species such as reed canary grass (*Phalaris arundinacea*) and bittersweet nightshade (*Solanum dulcamera*).

More aquatic-adapted plants such as water parsley (*Oenanthe sarmentosa*), hardstem bulrush (*Scirpus acutus*), pondweed species (*Potamogeton* spp), and the invasive yellow flag iris (*Iris pseudacorus*) were associated with the open water areas.

Tree species surrounding the wetlands and associated with upland habitat included western hemlock (*Tsuga heterophylla*), big-leaf maple (*Acer macrophyllum*), and Douglas fir (*Pseudotsuga menziesii*).
Common upland shrub species included common snowberry (*Symphiocarpus albus*), dull Oregon grape (*Mahonia nervosa*), vine maple (*Acer circinatum*), and osoberry (*Oemleria cerasiformis*).

Common herbaceous species associated with upland conditions include sword fern (*Polystichum munitum*) and wood sorrel (*Oxalis oregana*), as well as non-native herbaceous species such as herb-Robert (*Geranium robertum*).

Invasive non-native species were common at both sites, and include Himalayan blackberry (*Rubus armeniacus*), reed canary grass, English ivy (*Hedera helix*), English holly (*Ilex aquifolium*), and cherry laurel (*Prunus laurocerasus*). Twin Ponds Park, however, showed a high species richness of both native shrub and herbaceous species during the site visit.

Table 3.4-1—Wetland Locations, Classifications, Categories, Sizes, and Buffers

Wetland	Cross-Referenced Wetland Designation[A]	Location	Wetland Classification and Category			Wetland Size[E]		Habitat Score from Ecology Rating[F]	Buffer Width (feet)[G]
			Cowardin[B]	HGM[C]	City of Shoreline[D]	Square Feet	Acres		
A/B	WL-F	Paramount Open Space	PFO/OW	Depressional	III	30,179	0.693	6	165 ft.
C	WL-I	Paramount Open Space	PFO/PSS	Depressional	III	32,492	0.746	6	165 ft.
D	WL-I	Paramount Open Space	PFO	Depressional	III	3,165	0.073	5	105 ft.
E	WL-I	Paramount Open Space	PFO	Depressional	III	1,342	0.031	5	105 ft.
F	WL-I	Paramount Open Space	PFO/PEM	Depressional	III	17,036	0.391	6	165 ft.
G	WL-F	Paramount Open Space	PFO/PSS	Depressional	III	1,505	0.035	5	105 ft.
H	WL-F	Paramount Open Space	PEM	Slope	IV	>168	>0.004	5	40 ft.
I	WL-D	Twin Ponds Park	PFO/PEM/ OW	Depressional/ Riverine	III	211,167	4.848	6	165 ft.
J	WL-C	Twin Ponds Park	PEM	Riverine	III	9,384	0.215	5	105 ft.

Table 3.4-1 Notes:

A. Cross-references based on wetland identification conventions established in the *Thornton Creek and West Lake Washington Basins Characterization Report* (TetraTech/KCM, 2004) and the *Thornton Creek Watershed Plan* (R.W. Beck, 2009)

B. Cowardin et al. (1979) or National Wetland Inventory (NWI). Class based on vegetation: PFO = Palustrine Forested; PSS = Palustrine Scrub-Shrub; PEM = Palustrine Emergent; OW = Open Water.

C. Hydrogeomorphic (HGM) classification according to Brinson (1993).

D. Wetland rating according to the Shoreline Municipal Code, Chapter 20.80.330 (City of Shoreline, 2016) and based on the Washington State

Department of Ecology *Washington State Wetland Rating System for Western Washington 2014 Update.*

E. Wetlands sizes measured only within study area. ">" indicates that the wetland extends outside of study area.

F. Based on the Washington State Department of Ecology *Washington State Wetland Rating System for Western Washington 2014 Update*

G. Wetland buffer width according to the Shoreline Municipal Code, 20.80.330 (City of Shoreline, 2016) and habitat scores for the wetlands.

Aquatic and Upland Habitat Conditions

The wetlands and stream riparian corridors within the subarea provide habitat for aquatic and migratory species. Protecting these resources is a high priority of the City of Shoreline Municipal Code, which includes the Critical Areas Ordinance (as summarized in this section of the FEIS). Ecosystems in the subarea provide a variety of functions such as facilitating food chain production, providing habitat for nesting, rearing and resting sites for aquatic, terrestrial and avian species, and maintaining the availability and quality of water.

City of Shoreline Wetland Classifications and Buffers

The City of Shoreline has recently updated its wetland rating classification system, per SMC 20.80.320. Wetlands are classified as Category I through Category IV wetlands, based on the following criteria excerpted from the SMC.

1. *Category I. Category I wetlands are those that represent unique or rare wetland types, are more sensitive to disturbance than most wetlands, are relatively undisturbed and contain ecological attributes that are impossible to replace within a human lifetime, or provide a high level of functions. The following types of wetlands are Category I:*
    a. *Relatively undisturbed estuarine wetlands larger than one acre;*
    b. *Wetlands of high conservation value that are identified by scientists of the Washington Natural Heritage Program/DNR;*
    c. *Bogs;*
    d. *Mature and old-growth forested wetlands larger than one acre;*
    e. *Wetlands in coastal lagoons; and*
    f. *Wetlands that perform many functions well (scoring 23 points or more based on functions).*

2. *Category II. Category II wetlands are those that are difficult, though not impossible to replace and provide high levels of some functions. The following types of wetlands are Category II:*
    a. *Estuarine wetlands smaller than one acre, or disturbed estuarine wetlands larger than one acre;*
    b. *Interdunal wetlands larger than one acre or those found in a mosaic of wetlands; and*
    c. *Wetlands with a moderately high level of functions (scoring between 20 and 22 points)*

3. *Category III. Category III wetlands are those with a moderate level of functions, generally have been disturbed in some ways, can often be adequately replaced with a well-planned mitigation project, and are often less diverse or more isolated from other natural resources in the landscape than Category II wetlands. The following types of wetlands are Category III:*
    a. *Wetlands with a moderate level of functions (scoring between 16 and 19 points); or*
    b. *Interdunal wetlands between 0.1 and one acre.*

4. *Category IV. Category IV wetlands are those with the lowest levels of functions (scoring below 16 points) and are often heavily disturbed. These are wetlands that should be able to replace, or in some cases to improve. However, experience has shown that replacement cannot be guaranteed in any specific case. These wetlands may provide some important functions, and also need to be protected.*

Most of the wetlands on the Paramount Open Space and the Twin Ponds Park sites are categorized as Category III wetlands per the SMC and have habitat scores of 5 or 6 based on the Washington State Department of Ecology *Washington State Wetland Rating System for Western Washington* (2014 Update). Wetland H is a slope wetland with an emergent vegetation class, and is categorized as a Category IV wetlands per the SMC.

Per SMC 20.80.330, wetland buffers are based on wetland categories and on habitat scores—both higher wetland categories and higher habitat scores are reflected in a greater assigned buffer width. For the majority of wetlands in both the Paramount Open Space and Twin Ponds Park sites that have habitat scores of either 5 or 6 points, and buffer widths are, respectively, either 105 feet or 165 feet. Wetland H, as a Category IV wetland, is afforded a 40 foot buffer and that buffer is not dependent upon habitat scores per the SMC.

Per SMC 20.80.090, in all cases the standard buffer shall apply unless the Director determines that additional buffer width is necessary or reduced buffer is sufficient to protect the functions and values consistent with the provisions of SMC 20.80 and the recommendations of a qualified professional.

2015 Assessment Results for Streams

A total of seven stream reaches were identified in the vicinity of the Paramount Open Space and the Twin Ponds Park sites as part of the reconnaissance and assessment effort. **Table 3.4-2** lists the streams, stream classification, and buffers for the streams on the sites. Additional information on stream characterization follows.

Thornton Creek and Meridian Creek at Twin Ponds Park

Thornton Creek conveys drainage from approximately 1,300 acres of largely residential land in the City of Shoreline, at the point where if flows into Twin Ponds from the north. The stream passes through a residential neighborhood in a system of open channels, ditches, and pipes before discharging into the north pond in Twin Ponds Park. Thornton Creek then passes into the south pond prior to flowing through a long culvert beneath I-5.

During the reconnaissance, representative bankful width and bankful depth measurements taken for Thornton Creek were approximately 22 feet and 2 feet, respectively, taken at two locations downstream of the southern pond, and 8-10 feet and 2-3 feet, respectively, taken upstream of the northern pond. Riffles and glides were the dominant habitat units, and pool habitat was relatively scarce. Stream substrate consisted of stream gravels and fines, and embeddedness was high.

Riparian vegetation was considered moderately disturbed due to the density of non-native invasives such as Himalayan blackberry, Japanese/giant knotweed (*Polygonum cuspidatum/ sachalinenses*), and field bindweed (*Convovulus arvensis*), the nearby presence of human activities and land use, and the relatively young age of the tree canopy.

Table 3.4-2—Stream Locations, Classifications, and Buffers

Stream	Cross-Referenced Stream Reach Designation[H]	Location	Stream Typing		Standard Buffer Width (feet)[M]
			DNR[I]	City of Shoreline[L]	
Littles Creek	TC14	Paramount Open Space	NA[J]	F, non-anadromous	75 ft.
Littles Creek Tributary 1A	TC14	Paramount Open Space	NA[J]	F, non-anadromous	75 ft.
Littles Creek Tributary 2A	TC14	Paramount Open Space	NA[J]	Ns/--	45 ft./no buffer
Littles Creek Tributary 3A	TC14	Paramount Open Space	NA[J]	Ns/--	45 ft./no buffer
Littles Creek Tributary 4A	TC14	Paramount Open Space	NA[J]	Ns/--	45 ft./no buffer
Thornton Creek	TC3 & TC7	Twin Ponds Park	Np/F[K]	F, non-anadromous	75 ft.
Meridian Creek	TC4	Twin Ponds Park	NA[J]	F, non-anadromous	75 ft.

Notes:

H. Cross-references based on wetland identification conventions established in the *Thornton Creek and West Lake Washington Basins Characterization Report* (TetraTech/KCM, 2004)

I. Stream typing based on Washington Department of Natural Resources (DNR). Type Ns: non fish-bearing seasonal stream; Type Np: non fish-bearing perennial stream; Type F: fish bearing stream; Type S: Shoreline of the State.

J. Not Available—stream is not mapped by DNR.

K. Thornton Creek is rated as Type N downstream of the ponds, Type F within the ponds themselves.

L. Littles Creek Tributaries 2A, 3A, and 4A may be provisionally rated as Ns, or as stormwater ditches and thus not considered Waters of the State (see below).

M. Stream rating according to the Shoreline Municipal Code, Chapter 20.80.270 (City of Shoreline, 2016). Littles Creek Tributaries 2A, 3A, and 4A may be provisionally rated as Ns with 45 foot buffers, or as stormwater ditches with no buffers.

Large woody debris associated with the system was scarce and tended to consist of smaller pieces that provide lower in-stream habitat complexity and function.

Meridian Creek flows into the Twin Ponds Park site from the west, conveying flows from 350 acres, which are mostly residential. Almost the entirety of Meridian Creek exists as piped conveyance systems upstream of Evergreen School. Significant open channel portions of Meridian Creek are limited to approximately 500 feet within Twin Ponds Park and 340 feet within the Evergreen School property. Also known as Evergreen Creek, Meridian Creek is a channelized system in relatively poor condition that is associated with a riparian wetland (Wetland J).

Meridian Creek is likely an intermittent system, given that previous studies had indicated that the system dries up at times (TetraTech/KCM, 2004). Dominant substrate consisted of fines, particularly upstream of the point where the Meridian Creek system discharges into the southern pond.

Bankful width and depth were estimated at 9-12 feet and 2-2.5 feet, respectively, at points in the system where channelization was more pronounced. Similar to Thornton Creek, riparian vegetation is moderately disturbed due to the presence of invasives, proximal land use and activities, and relatively young age of the canopy.

Littles Creek and Tributaries

The Littles Creek system consists of the mainstem Littles Creek and a number of tributaries. The system enters the Paramount Open Space area from the north and flows southward through the site, and is associated with a number of depressional wetlands. The Littles Creek subbasin drains approximately 466 acres.

The Littles Creek stream system on the Paramount Open Space area consists of the mainstem Littles Creek and four associated tributaries. Tributaries 1A and 3A confluence with the mainstem Littles Creek on the Paramount property, while Tributary 2A is culverted and discharges into Littles Creek to the south. Tributary 4A occurs on the Paramount property to the north and may have linked Tributary 1A and the mainstem Littles Creek in the past.

Tributary 2A appears to be a constructed stormwater ditch, running along the toe of a slope behind several residential structures and receiving flow from a low point on the roadway of NE 147th Street. The flow path for this tributary is approximately 3 feet in width and approximately 1 foot in depth. Flows are seasonal, with no flow observed in Tributary 2A during the site visits and willowherb rooted in the channel. Stream substrate consists of fines and organic soils. Tributary 2A has bank armoring that consists of concrete fragments and bed armoring consisting of quarry spalls, and discharges into a 16-inch CMP culvert for approximately 218 feet prior to confluencing with the mainstem Littles Creek off-site. The City of Shoreline maps Tributary 2A as a ditch in the surface water drainage mapping data.

Tributary 3A appears to have been straightened and ditched in the past, likely to improve conveyance during storm events. Representative bankful width and depth for the system is approximately 3 feet and approximately 1.2 feet, respectively. Flows are seasonal, and substrate consists of fines and organic soils saturated to the surface during the site visits. Riparian habitat for both Tributary 2A and 3A is highly disturbed, and consists of a mix of open and forested edge habitat, with a dominant invasive plant community comprised of Himalayan blackberry. Large woody debris is absent from both tributary systems. Similar to Tributary 2A, the City of Shoreline maps Tributary 3A as a ditch in the surface water drainage mapping data.

Tributary 4A has a representative bankful width and depth of 5-6 feet and 1.5-2 feet, respectively. Under existing conditions, a berm appears to separate Tributary 4A from Tributary 1A, although the City of Shoreline maps Tributary 4A and 1A as connected in the surface water drainage mapping data. Based on information from the Thornton Creek and West Lake Washington Basins Characterization Report (TetraTech/KCM, 2004), City of Shoreline GIS data, and the channel dimensions, Tributary 4A was very likely connected to Tributary 1A in the past. Currently it appears to be a backwater channel for the mainstem Littles Creek. Tributary 4A may be a considered as either a constructed surface water feature linking the mainstem Littles Creek and Tributary 1A, or as a seasonally active drainage.

The mainstem Littles Creek and Tributary 1A are larger than the above tributaries. As noted above, Tributary 1A appears at one time to have been a diversion flow path from the mainstem Littles Creek via Tributary 4A, reconnecting with the mainstem near the southern end of the Paramount Open Space area. Currently, Tributary 1A is associated with Wetlands C and A/B, showing poor channelization and sheet flow dynamics in portions of the wetlands, and relatively well-defined channels in other parts of the wetlands.

Representative bankful widths and depths for Tributary 1A are 6-8 feet and 0.5 feet, respectively, near the culvert, with a more incised condition to the north (bankful width and depth of approximately 5 feet and 2 feet, respectively). Stream habitat units consist of riffles and glides interspersed with poorly channelized wetland and ponded units. Substrate is dominated by fines in the lower energy areas, with gravels present in the riffle habitat units. Spalls and rounded cobbles appear to have been placed in reaches of the Tributary 1A system to dissipate streamflow energy. Although large wood is not abundant in the Tributary 1A system, smaller wood is present and relatively abundant. Riparian habitat is relatively abundant and shows a low to moderate disturbance regime, with abundant patches of dominant non-native invasive species such as Himalayan blackberry and English ivy.

Bankful width and bankful depth for the mainstem Littles Creek ranges from 5-7 feet and 1-1.3 feet, respectively. Gravels and fines are the dominant stream substrate, with quarry spalls scattered in portions of the stream reaches—particularly near trail culverts where erosive flows may be present. Stream habitat consists primarily of riffles, with very few pools. Although large wood is not abundant in mainstem Littles Creek, smaller wood is present and relatively abundant. Similar to Tributary 1A, riparian habitat for the mainstem Littles Creek is relatively abundant and shows a low to moderate disturbance regime, and a relatively high diversity of native plant species. However, non-native invasive species such as Himalayan blackberry, Japanese/giant knotweed, and English ivy make up a dominant component of the vegetative community.

Within the Paramount Open Space area, the banks of Littles Creek appear relatively stable, although there are areas where minor undercutting and erosional scarring were observed. Immediately to the south of the Paramount Open Space area, two culverts on privately held parcels impose a known partial fish passage blockage and an unknown fish passage blockage, respectively. Somewhat further to the south, a culvert conveying Littles Creek beneath NE 145th Street imposes a complete fish passage blockage based on WDFW Salmonscape information, which also identifies other fish passage barriers along Littles Creek downstream of NE 145th Street.

Fisheries

In general, fish habitat is relatively poor throughout the Thornton Creek basin, due primarily to fish passage barriers, riparian encroachment, and bank hardening. That said, a number of observations indicate that Thornton Creek in the vicinity of the Twin Ponds Park site contains salmonid species—primarily resident cutthroat trout (*Onchorhynchus clarkii*) (WDFW, 2015a; TetraTech/KCM, 2004). Although there is some anecdotal evidence that juvenile coho salmon have been observed in Thornton Creek in the vicinity of Twin Ponds Park, this has been attributed to release of juveniles into the system through elementary school programs (given that the lengthy downstream culverts crossing under I-5 are considered complete fish passage barriers to anadromous salmonids).

Meridian Creek is linked to the Thornton Creek and Twin Ponds system via a surface water connection during at least a portion of the year, with no fish passage barrier interposed between the two streams. Meridian Creek is also considered to provide potential habitat for cutthroat trout during a portion of the year. Most of Meridian Creek is fairly shallow and stagnant, resembling a backwatered ditch affecting the habitat quality. The Thornton Creek Watershed Plan concludes that resident (non-anadromous) salmonid use of the system from the mouth of Meridian Creek upstream for few hundred feet (approximately one third to one half of the 500-foot open channel length) is a reasonable presumption (R. W. Beck, 2009).

Salmonid presence is not well documented for Littles Creek and its tributaries (WDFW, 2015a; WDFW, 2015b). Previous studies indicated that salmonid presence was unlikely in the system or that salmonids were definitively absent (The Watershed Company, 2009; R. W. Beck, 2009), or resulted in no occurrence of fish during surveys (Tabor *et al*., 2010). Existing fish passage barriers downstream of the Paramount Open Space preclude the presence of anadromous salmonids (WDFW, 2015b).

Cutthroat trout or any other fish species were not observed during the fieldwork. However, the presence of some fish species is likely in the two perennial reaches of the Littles Creek system in the Paramount Open Space—namely, Littles Creek mainstem and Littles Creek Tributary 1A. Perennial stream reaches typically provide habitat for non-salmonid species such as sculpin, three-spined stickleback, and assorted minnow species (e.g. red-sided shiners, dace, etc.).

Based on the habitat in the mainstem Littles Creek and the Littles Creek Tributary 1A, and on SMC 20.80.270.B.5, a provisional stream rating of Type F - Non-anadromous classification is warranted. Littles Creek Tributaries 2A, 3A, and 4A appear to have an intermittent (seasonal) hydrologic regime and are unlikely to provided functional fish habitat. In addition, Tributaries 2A, 3A, and 4A may be considered as stormwater/drainage features that were established/installed. As such, these tributaries would warrant either a Type Ns (season nonfish habitat stream) designation and associated buffer, or would be considered as artificially constructed features that would receive no buffer (see **Table 3.4-2**).

City of Shoreline Stream Classifications and Buffers

The City of Shoreline has its own stream classification system, per SMC 20.80.270 for classification of Fish and Wildlife Habitat Conservation Areas—specifically, Waters of the State, described below. Streams are classified based on the criteria excerpted from the SMC, also described below.

SMC 20.80.270.B.5. Waters of the State

Waters of the State include lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and watercourses within the jurisdiction of the state of Washington, Waters of the State are classified in WAC 222-16-030.3. Streams and wetlands and their associated buffers that provide significant habitat for fish and wildlife are those areas where surface waters produce a defined channel or bed, not including irrigation ditches, canals, storm or surface water runoff devices or other entirely artificial watercourses, unless they are used by fish or are used to convey streams naturally occurring prior to construction. A channel or bed need not contain water year-round; provided that there is evidence of at least intermittent flow during years of normal rainfall.

Streams shall be classified in accordance with the Washington Department of Natural Resources water typing system (WAC 222-16-030) hereby adopted in its entirety by reference and summarized as follows:

a. *Type S: streams inventoried as "shorelines of the state" under Chapter 90.58 RCW and the rules promulgated pursuant to Chapter 90.58 RCW;*

b. *Type F: streams which contain fish habitat. Not all streams that are known to exist with fish habitat support anadromous fish populations, or have the potential for anadromous fish occurrence because of obstructions, blockages or access restrictions resulting from existing conditions. Therefore, in order to provide special consideration of and increased protection for anadromous fish in the application of development standards, Shoreline streams shall be further classified as follows:*

    i. *Anadromous fishbearing streams (Type F-anadromous). These streams include:*

        1. *Fish bearing streams where naturally recurring use by anadromous fish populations has been documented by a government agency;*

        2. *Streams that are fish passable or have the potential to be fish passable by anadromous populations, including those from Lake Washington or Puget Sound, as determined by a qualified professional based on review of stream flow, gradient and natural barriers (i.e. natural features that exceed jumping height for*

salmonids), and criteria for fish passability established by the Washington Department of Fish and Wildlife; and

3. *Streams that are planned for restoration in a six-year capital improvement plan adopted by a government agency or planned for removal of the private dams that will result in a fish passable connection to Lake Washington or Puget Sound; and*

ii. *Non-anadromous fishbearing streams (Type F-non-anadromous). These include streams which contain existing or potential fish habitat, but do not have the potential for anadromous fish use due to natural barriers to fish passage, including streams that contain resident or isolated fish populations.*

The general areas and stream reaches with access for anadromous fish are indicated in the City of Shoreline Stream and Wetland Inventory and Assessment (2004) and basin plans. The potential for anadromous fish access shall be confirmed in the field by a qualified professional as part of a critical area report.

SMC 20.80.270.B.5 goes on to classify non-fish bearing streams as provided in WAC 222-16-030:

c. *Type Np: perennial nonfish habitat streams;*

d. *Type Ns: seasonal nonfish habitat streams; and*

e. *Piped stream segments: those segments of streams, regardless of their type, that are fully enclosed in an underground pipe or culvert.*

Thornton Creek and Meridian Creek are categorized as Type F, non-anadromous streams, based on the documented presence of cutthroat trout and other fish in Thornton Creek and the Twin Ponds, the surface water connection and potential for use of the Meridian Creek system by cutthroat trout and other fish during some portion of the year, and the existing complete lack of accessibility to anadromous species.

The Littles Creek mainstem and the Littles Creek Tributary 1A are provisionally categorized as Type F, non-anadromous streams based on the perennial hydrologic regime of these two reaches, the available stream habitat for aquatic biota, and the relatively high likelihood of some species of fish utilizing this habitat. Per the SMC, Type F non-anadromous streams are defined as providing fish habitat for a variety of different species. As noted above, perennial stream reaches typically provide habitat for non-salmonid species such as sculpin, three-spined stickleback, and assorted minnow species (e.g. red-sided shiners, dace, etc.). Based on the habitat in the mainstem Littles Creek and the Littles Creek Tributary 1A, and on the SMC, a provisional stream rating of Type F, non-anadromous is warranted.

As noted above, the Littles Creek Tributaries 2A, 3A, and 4A appear to have an intermittent (seasonal) hydrologic regime and are unlikely to provided functional fish habitat. In addition, Tributaries 2A, 3A, and 4A may be considered as stormwater/drainage features that were established/installed.

As such, these tributaries would warrant either a Type Ns designation and associated buffer, or would be considered as artificially constructed features that would receive no buffer (Table 2).

Shoreline Municipal Code (SMC)/Critical Areas Ordinance (CAO)

The City Critical Areas Ordinances (CAO), was updated on December 7, 2015 and in effect on February 1, 2016. The CAO was reviewed in the context of how zoning changes from the proposed alternatives could create additional buffers with building setbacks, or modify existing buffers. SMC 20.80.015(A) states the provisions of the CAO shall apply to all land uses and within all zoning designations in the City of Shoreline. Key provisions of the CAO are summarized below.

- Per SMC 20.80.015, all land uses and proposed development must comply with the City's CAO. Proposed impacts to critical areas or critical area buffers must comply with critical areas standards and are subject to project review and approval by the Planning Director.

- Per SMC 20.50.020(D), lots divided by a residential zone boundary may transfer density from the lesser residential density portion of the lot to the greater residential portion.
    - Residential transfer from a greater residential portion to the lesser residential portion may be allowed when said transfer contributes to preservation of critical areas or other natural features.

- Per SMC 20.50.300(G), any disturbance to vegetation within critical areas and their corresponding buffers is subject to the procedures and standards contained within the critical areas chapter of the Shoreline Development Code, Chapter 20.80 SMC, Critical Areas, in addition to the standards of the SMC 20.50.300(G). The standards which result in the greatest protection of the critical areas shall apply.

- Removal of trees where applicable, typically exempt from permit requirements of 20.50.300 per SMC 20.50.310, would not be exempt if the activity takes place within a critical area or critical area buffer.

- Partial exemptions from the permit requirements of 20.50.300 do not pertain to development activities occurring within a critical area or critical area buffer. Disallowed partial exemptions include tree removal of significant trees, tree removals based on lot size, and landscape maintenance and alterations based on square footage limits.

Wooded area in the vicinity of Paramount Open Space

- If tree removal is to occur on a site that includes critical area and critical area buffer, tree removal within the critical area and buffer must be consistent with the CAO standards, and retention of 30 percent of significant trees on the site vs. retention of 20 percent of significant trees on a site with no critical areas or critical area buffers is required (SMC 20.50.350).
    - Replacement of removed trees with appropriate native trees at a ratio determined by the Director will be required in critical areas.

- Per SMC 20.50.460, existing vegetated critical areas may substitute for required landscaping.

- Per SMC 20.50.520 (K), <u>new</u> landscape material shall be indigenous (native) plant species within critical areas or their buffers.
    - Normal and routine maintenance and operation of <u>existing</u> landscaping and gardens within critical areas and critical areas buffers are exempt from the SMC CAO requirements, per SMC 20.80.030(J) and provided they comply with all other regulations in that chapter. including pruning of protected trees consistent with SMC 20.50.350(E)

A number of SMC exemptions may be relevant to future redevelopment (see generally, SMC 20.80.030 Exemptions). These exemptions may allow for new utility activities and modification of existing structures and infrastructure to occur within critical areas and critical area buffers as redevelopment proceeds. However, per SMC 20.80.030, any otherwise exempt activities occurring in or near a critical area or critical area buffer should meet the purpose and intent of SMC 20.80.010 and should consider on-site alternatives that avoid or minimize impacts.

- Per SMC 20.80.030, exemptions to the CAO requirements are allowed for public water, electric and natural gas distribution, public sewer collection, cable communications, telephone, utility and related activities undertaken pursuant to City-approved best management practices. Per SMP 20.80.030, additional parameters concerning replacement and/or relocation of these facilities pertain.
    - Repair and maintenance of existing private connections to public utilities and private stormwater management facilities consistent with best management practices and best available science. Revegetation of disturbed areas is required to be native vegetation, unless the existing, non-native vegetation is re-established with no change to type or extent.

- Maintenance, operation, repair, modification or replacement of publicly improved roadways or City-authorized private roadways and associated stormwater drainage systems, as well as publicly improved recreation areas, as long as such activity does not involve the expansion of uses and/or facilities into previously unimproved rights of ways, portions of rights of ways, or previously unimproved areas in the case of recreation sites. In addition, such activities cannot alter a wetland or watercourse, such as culverts or bridges, or result in the transport of sediment or increased stormwater. Retention and replanting of native vegetation shall occur wherever possible along the right-of-way improvement and resulting disturbance.
- Activities such as recreational area operations, repair, maintenance, modification and/or replacement are exempt so long as any such activity does not involve the expansion of facilities and existing improvements into a previously unimproved portion of critical areas or required buffers.

- Emergencies; minor conservation and enhancement activities; removal of active and non-imminent hazard trees subject to the provisions of SMC 20.80.30(G); site investigations; passive outdoor activities; normal maintenance; and minor activities determined by the City to have minimal impacts to a critical area are all potentially exempt activities.

- The application of herbicides, pesticides, organic or mineral-derived fertilizers, or other hazardous substances, if necessary, provided that their use shall be restricted in accordance with state Department of Fish and Wildlife Management Recommendations and the regulations of the state Department of Agriculture and the US Environmental Protection Agency.

A number of allowed activities may occur within critical areas and/or critical area buffers. Allowed activities shall be reviewed and permitted or approved by the City and any other agency with jurisdiction, but do not require submittal of a separate critical area report, unless such submittal was required previously for the underlying permit. The Director may apply conditions to the underlying permit or approval to ensure that the allowed activity sufficiently protects critical areas.

- Per SMC 20.80.040, allowed activities within critical areas or their buffers include structural modifications of, additions to, maintenance, repair, or replacement of legally non-conforming structures consistent with SMC 20.30.280, and which currently do not meet the setback or critical areas or critical buffer requirements, if the replacement or related activity does not increase the existing building footprint or area of hardscape within the critical area or the critical area buffer. A Stormwater Pollution Prevention Plan (SWPPP) would be required consistent with the adopted stormwater manual and clearing limits that adequately protect the critical area.

School children, teachers, and parents from Evergreen School on a field trip to Twin Ponds Park (north shore of the north pond)

- Per SMC 20.80.040, allowed activities include demolition of structures located within critical areas or their buffers, excluding demolition of structures necessary to support or stabilize landslide hazard areas, and also would be subject to approval of a SWPPP consistent with the adopted stormwater manual and clearing limits that adequately protect the critical area.

- Permit requests subsequent to previous critical area review by the City of Shoreline are considered allowed, subject to criteria established in SMC 20.80.040(C)(3).

As previously stated, the City has recently updated their CAO, adopting updates to the City Code (SMC 20.80) on December 7, 2015 with the new regulations in effect on February 1, 2016. The goals of the update were to: 1) Update the regulations for consistency with Best Available Science as required by the State, 2) Provide predictability and clarity by adding standards for critical area report submittals, and 3) Modify problematic and unclear sections of the code.

Substantial changes in the updated City of Shoreline CAO include adoption of the Washington State Department of Ecology *Washington State Wetland Rating System for Western Washington: 2014 – Update*; changes to wetland categorization that reflect Ecology's rating system; significant increases in wetland buffer sizes; alterations to the City's stream typing methodology in accordance with Washington Department of Natural Resources water typing system (WAC 222-16-030); and small changes to stream buffers. Standard wetland buffers under the updated City CAO show the largest increase, typically increasing an additional 50-60 feet compared to the wetland buffers under the previous CAO requirements. Increase in buffer widths on the Paramount Open Space and Twin Ponds

Park sites would likely further encumber adjacent, privately owned properties as a result.

Standard buffer widths for stream systems associated with the Paramount Open Space and Twin Ponds Park sites change relatively little under the updated City of Shoreline CAO. In the case of Type F reaches (Thornton Creek, Meridian Creek, Littles Creek mainstem, and Littles Creek Tributary 1A), buffer sizes either increase an additional 10 feet or actually are reduced based on lack of anadromous salmonids in the systems under the updated CAO. Under the updated CAO, other stream reaches in the Paramount Open Space and Twin Ponds Park sites generally retain similar buffer widths compared to the previous CAO requirements, or show an overall reduction in buffer width. Stream buffer widths on the Paramount Open Space and Twin Ponds Park sites would not further encumber adjacent, privately owned properties as a result.

Buffer averaging is allowed under the updated CAO; however, buffer reductions allowable under the previous CAO no longer pertain. For example, per SMC 20.80.330, buffer averaging for wetlands and streams is allowable as follows.

SMC 20.80.330(A)(5) Buffer averaging to improve wetland protection may be permitted when all of the following conditions are met:

a. *The wetland has significant differences in characteristics that affect its habitat functions, such as a wetland with a forested component adjacent to a degraded emergent component or is a "dual-rated" wetland with a Category I area adjacent to a lower rated area;*

b. *The buffer is increased adjacent to the higher functioning area of habitat or more sensitive portion of the wetland and decreased adjacent to the lower functioning or less sensitive portion as demonstrated by a critical areas report from a qualified wetland professional;*

c. *The total area of the buffer after averaging is equal to the area required without averaging; and*

d. *The buffer at its narrowest point is never less than either three-fourths of the required width or 75 feet for Category I and II, 50 feet for Category III, and 25 feet for Category IV, whichever is greater.*

Per SMC 20.80.274, buffer averaging for stream systems is allowed if:

SMC 20.80.275(I)(3) Habitat Buffer Averaging. The Director may allow the recommended fish and wildlife habitat area buffer width to be reduced in accordance with a critical area report, the best available science, and the applicable management recommendations issued by the Washington Department of Fish and Wildlife, only if:

a. *It will not reduce stream or habitat functions;*

b. *It will not adversely affect fish and wildlife habitat;*

c. *It will provide additional natural resource protection, such as buffer enhancement;*

d. *The total area contained in the buffer area after averaging is no less than that which would be contained within the standard buffer; and*

e. *The buffer area width is not reduced by more than twenty-five percent (25%) in any location.*

Subsurface and Groundwater Conditions

A variety of geologic, subsurface soil, and groundwater conditions exist within the subarea. The Thornton Creek and West Lake Washington Basins Characterization Report prepared by Tetra Tech for the City of Shoreline in 2004 summarizes soil types in the Thornton Creek basin from the soil survey compiled in 1952 by the US Soil Conservation Service (SCS). The Thornton Creek Basin has a dominant soil type of Alderwood gravelly sandy loam, which is found in approximately 88 percent of the basin. Alderwood soils can drain slowly during heavy rains and cause rainfall to pond or run off in sheet flow. The rest of the soils, found in 3 percent or less of the total basin area, include: Norma fine sandy loam, Everett gravelly sandy loam, Greenwood peat, Mukilteo peat, and Rifle peat. The peat soil types are hydric soils frequently supporting wetlands. The peat soils are predominantly located in Twin Ponds and Ronald Bog parks. Portions of Twin Ponds and Ronald Bog peat areas were mined for peat moss decades ago, which altered the hydrologic systems of the area.

Geologic conditions may be considered potentially hazardous when they are subject to liquefaction-prone subsurface conditions, seismic hazards, and/or if they contain areas of peat deposits that may be prone to later settlement. Landslide prone areas include steep slopes that also are regulated for potential erosion hazards. To address these hazards, potential development projects must study site-specific conditions and develop appropriate engineering solutions, which may include avoiding these areas or mitigating these conditions, depending on their extent, through various treatments and engineering solutions.

The City of Shoreline has analyzed and mapped potential geologic hazard areas in the city, and provides emergency management procedures to address these as well as other potential hazards and emergency situations. Refer to: http://www.cityofshoreline.com/emergency/emergency-management/hazards-in-shoreline for additional information and mapping.

General subsurface conditions in the vicinity of Paramount Open Space and Twin Ponds Park, in some cases indicative of conditions throughout the subarea, were analyzed by GeoEngineers, Inc. in a technical memorandum that was part of the DEIS Addendum published in February 2016. This analysis was based on a review of available information, geologic maps, and reports (see Chapter 5—References). Geotechnical considerations for sites with high groundwater levels and/or peat soils also were assessed.

Surficial geologic units in the subarea and surrounding region are a result of glacial and postglacial processes (see **Figure 3.4-8**). Published geologic information for the area includes a geologic map prepared by Booth et. al. (2008) and information presented in a Thornton Creek Basin Characterization Report (2004).

Mapped surficial geology indicates the presence of glacial till with a band of advance outwash along the I-5 corridor. Glacial till and advance outwash are glacially overridden. Glacial till typically consists of dense to very dense/hard silt, sand, and gravel of variable proportions. Advance outwash typically consists of dense to very dense sand and gravel, with variable silt content.

Also mapped in the area, but less predominant, are zones of recessional outwash and ice-contact deposits, and isolated deposits of peat. Recessional outwash and ice-contact deposits were deposited in the wake of the retreating glacier, and vary from loose to medium dense. Recessional outwash typically consists of stratified sand, with occasional lenses of silty sand, silt and gravel, and ice-contact deposits are similar, but less well-sorted and characterized by higher silt content and lenses of till.

Peat Conditions

According to the 2004 Thornton Creek Basin Characterization Report, the area around Ronald Bog, Twin Ponds, and Meridian Park was a large peat bog historically. Mining of peat in the area occurred over several decades, creating water features. Areas of peat soil are still known to exist in the subarea vicinity, particularly in the area of Twin Ponds Park. Peat lenses consist of wood and other organic debris, and are typically encountered in wetlands, former lake bottom areas, or recessional outwash channels. Peat is typically very loose/soft and highly compressible.

Groundwater

Available groundwater information from boring and test pit logs reviewed for this environmental analysis suggest the presence of perched water tables over dense glacial till and other dense and low permeable glacial soils in some locations in the subarea.

Infiltration Characteristics

Infiltration of stormwater runoff is an important tool of state and local stormwater management regulations. Infiltration should be provided on site if possible, or if not possible, other green stormwater infrastructure and low impact development (LID) methods and best practices for managing stormwater runoff to control flows, improve water quality, and enhance habitat systems must be implemented. Given the conditions described above, the infiltrative capacity of the existing soils and ground is highly variable. Geotechnical analysis completed as part of each future project development would need to determine the specific infiltrative capacity of soils on the specific site to inform stormwater management design and engineering techniques.

Liquefaction Potential

Liquefaction-prone areas are typically underlain by cohesionless soils of low density, usually in association with a shallow groundwater table, or loose to medium dense, clean to moderately silty sand below the groundwater level. These areas can lose substantial strength during earthquakes. This is due to a phenomenon where soils experience a rapid loss of internal strength as a consequence of strong ground shaking. Ground settlement, lateral spreading and/or sand boils may result from soil liquefaction. If not properly planned and designed, structures supported on liquefied soils can suffer foundation settlement or lateral movement that can be severely damaging to the structures and threaten safety of inhabitants.

Available data and mapping also indicate the presence of potentially liquefiable soils in a small portion of the subarea. Refer to **Figure 3.4-9** for a map of potential liquefaction areas in the vicinity of the subarea. It should be noted that this mapping is general, and as part of individual site development, project proponents study the specific surficial and geotechnical conditions at the subject site. With this specific site study,

Low Impact Development (LID)

LID is a design approach to managing stormwater runoff and land development strategy applied at the parcel and subdivision scale. LID emphasizes conservation and use of on-site natural features integrated with engineered, small-scale hydrologic controls to more closely mimic predevelopment hydrologic functions.

The approach, also called green stormwater infrastructure, attempts to closely replicate pre-development hydrology of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source.

engineering recommendations about how to treat specific soils conditions can be developed. Potential mitigation measures vary based on the risk for liquefaction and the level of planned improvements at each site. These are described in more detail later in this section of the FEIS.

Surface Water Management

Service Provider

The City of Shoreline owns and maintains the public stormwater drainage utility within its boundaries. The City of Shoreline Surface Water Master Plan (adopted in 2005, updated in 2011, and scheduled for the next update in 2017) outlines the surface water management program adopted by the City.

Existing Features and Facilities

Several existing features in the subarea provide important stormwater management functions. The wetlands and ponds within Twin Ponds Park and in the Paramount Open Space area provide some attenuation for peak stormwater flows, as well as water quality enhancement.

Additionally, there are several smaller-scale detention and water quality facilities within the subarea. These include publicly and privately owned underground stormwater detention tanks and vaults of varying sizes at multiple locations. There are three existing City-owned low impact development (LID) facilities within or directly adjacent to the subarea. These facilities are bioretention systems that provide water quality treatment. One bioretention system is along 17th Avenue NE, between NE 150th Street and NE 145th Street. A second bioretention swale, located at NE 148th Street and 5th Avenue NE, has recently been constructed. There is also a small bioretention facility at 15209 Wallingford Place, just west of the subarea.

Some limited areas adjacent to Thornton Creek along the west side of I-5 and immediately around the ponds within Twin Ponds Park are shown as areas subject to periodic flooding based on the Proposed FEMA Floodplain Map, dated July 2012.

In addition, public comments gathered at various meetings during the subarea planning process indicate some locations in the subarea experience periodic localized flooding and drainage problems due to the existing aging infrastructure system (see more discussion below).

Surface Water Collection Systems

Table 3.4-3 summarizes the total surface water facilities managed and maintained by the City of Shoreline (taken from the Surface Water Master Plan). **Table 3.4-4** summarizes the surface water pipes within the subarea. The majority of pipes within the subarea are concrete; other common pipe materials include corrugated metal and plastic.

Much of the main branch of Thornton Creek within Shoreline south of N 163rd Street flows within the I-5 right-of-way owned by WSDOT. An exception to this, the 2,400-foot-long low-flow main channel, which branches westward at the flow splitter behind 2330 N 155th Place, is located outside the I-5 right-of-way. This low-flow main channel runs southward through Twin Ponds Park before reentering the WSDOT I-5 right-of-way. At this location, the low-flow main channel reconnects with a parallel 1,700-foot-long high-flow bypass channel.

While the City was incorporated in 1995, most areas of Shoreline had been developed by the 1970s. Consequently, the majority of the City's surface water infrastructure is over 40 years old and is approaching or has exceeded the typical 50-year life expectancy.

Table 3.4-3 Surface Water Drainage System Infrastructure

Drainage System Component (City Wide)	Estimated Quantity	Unit
Surface water pipe	640,000	Linear Foot (LF)
Catch Basins	7,626	Each
Ditches	150,000	LF
City Owned Stormwater Facilities	34	Each
City Owned Water Quality Facilities	37	Each
Dams	5	Each
Privately Owned Stormwater Facilities	263	Each
Pump Stations	8	Each

Table 3.4-4 Surface Water Drainage System Infrastructure

Subarea Drainage System Components	Estimated Existing Quantity	Unit
Surface water pipe (4" to 8" diameter)	5,400	LF
Surface water pipe (12" to 18" diameter)	29,200	LF
Surface water pipe (greater than 18" diameter)	8,000	LF

Many of the streets within the subarea do not possess curb and gutter. Runoff is typically collected by shallow, informal roadside swales, raised pavement edges or berms along asphalt roadways, and catch basins and then conveyed along a series of ditches and pipes. In some areas lacking a formal drainage system, localized sheet flow runoff disperses to adjoining pervious areas. The typical conveyance system within the subarea consists of pipe conveyance along arterials (principal, minor, and collector) with ditches or less formal systems (and occasional piped systems) along the smaller local secondary streets. Within the subarea, Meridian Avenue N, 5th Avenue NE, 15th Avenue NE, and N/NE 155th Street have curb and gutter collection with piped conveyance.

With development/redevelopment projected within the subarea, many of the local secondary streets would be improved to accommodate higher volumes of vehicles and pedestrians. When this occurs, shallow swale and raised edge drainage collection areas and areas lacking formal drainage would be converted to curb, gutter, and sidewalk, requiring installation of new conveyance networks with detention and treatment facilities. These street and stormwater system improvements would occur gradually over time to serve new development as it is built.

Per current SMC 20.70, redevelopment projects are generally required to provide frontage improvements, constructed at the developer's expense. These improvements can include dedication of right-of-way, new curb and gutter, new or improved sidewalks, drainage improvements, pavement overlays, or amenity zone landscaping. Amenity zone landscaping improvements could potentially include bioretention swales to provide water quality treatment and flow control mitigation for the adjacent public right-of-way. Further details regarding potential bioretention use for redevelopment-installed amenity zones within the right-of-way are yet to be determined by the City.

Current Demand

As part of this study, surface water runoff within the subarea was estimated using the Rational Method. The analysis provided a rough estimate of change in unmitigated peak discharge through the City's surface water conveyance system within the subarea during a 25-year storm event, for each zoning option. Percent impervious surface area for the subarea under existing conditions was compared to proposed improvements. In order to assess surface water runoff generation within the subarea, this analysis references the Seattle Public Utilities (SPU) methods for computing stormwater fees for residential units within the City of Seattle and neighboring communities. The SPU stormwater fee structure provides a relative impervious surface area based on average lot size and type of development. This FEIS study estimated the amount of stormwater reaching the municipal surface water collection system based the range of parcel sizes.

The analysis of change in peak discharge was completed for DEIS and FEIS analysis and planning purposes only, and generally should be considered a conservative overestimation of actual expected post-redevelopment conditions. This is because stormwater management regulations require development to control and mitigate flows (in addition to providing water quality treatment). While the analysis generally represents an overestimation of potential peak flows (because these would be controlled and mitigated on a per site basis), it does serve the purpose of quantifying the *unmitigated* potential increase in surface water discharge that potential zoning increases would have on the current surface water collection system.

Mitigation to this unmitigated condition would occur through compliance with stormwater management regulations as development is implemented.

This simplified analysis has no bearing on the City's existing Surface Water Master Plan. The specific extent of improvements and exact size of conveyance infrastructure to serve each development project in the subarea would be determined later through hydraulic modeling and engineering design associated with each project. This future analysis and design would then apply current redevelopment regulations (which typically lead to a net decrease in peak flows leaving the site).

Runoff from commercial and institutional development was analyzed based on the assumption that the majority of future development/redevelopment would have similar impervious surface areas due to the mixed use/multifamily patterns of land use proposed. Under this assumption, the average runoff factor assumed for the proposed mixed use/multifamily development would be 0.76 (76 percent impervious). This is based on the SPU stormwater fee structure matrix for "very heavy residential development", as shown in **Table 3.4-5** depicts the estimated percentage of impervious surface area for residential homes, based on size.

The City of Shoreline's surface water conveyance system was analyzed using the Rational Method, based on a 25-year storm event, and the percent of impervious surface area for each zone. Calculations by area (in acres) were multiplied by the applicable average runoff factor in **Table 3.4-5** for each zoning/density type. (Example: R-6 zone = 7,000 to 10,000 square foot lots with an average runoff factor of 0.48.)

Calculations were based on Chapter 3 of the 2009 King County Surface Water Design manual: 25-year, 24-hour isopluvial showed an average 2.75 inches of precipitation; typical time of concentration was estimated at 30-minutes for each subbasin within the subarea. The 30-minute concentration time was estimated as a relative average for water to flow over various land surfaces and slopes such as grass, pavement, forest, and through collection pipes before connecting to a surface water trunk main.

Surface water runoff rates were estimated based on the following Rational Method calculation (*Peak Flow in cubic feet per second/cfs = Runoff Factor [see Table 3.4-2] x Area [acres] x 2.75 [25-year storm precipitation amount in inches] x 0.29 [peak runoff factor for a 30-minute time of concentration]).*

Using the Rational Method provides a conservative estimate of the peak flows for each alternative, as discussed earlier. These flows were used as a comparison representing the percent increase for *unmitigated* flow due to the increased impervious area associated with the planned action alternatives. New developments would be required to install measures to control the rate and amount of surface water discharging from a site, to prevent the risk of flooding and to reduce the need for large downstream treatment and collection facilities.

Table 3.4-5—Estimated Impervious Surface Area for Residential Homes

Small Lot Residential

Class	SF	% Impact	Avg. Runoff Factor
Tier A	<3,000	N/A	0.65
Tier B	3,000 to < 5,000	N/A	0.53
Tier C	5,000 to < 7,000	N/A	0.51
Tier D	7,000 to < 10,000	N/A	0.48

Future development/redevelopment projects would be required to control surface water and stormwater runoff flows, to minimize flooding and also to maintain the natural hydrologic regime of the surrounding area. As a result, flows would generally decrease net runoff from the project sites.

General Service/Large Lot Residential

Undeveloped	Regular	0-15%	0.18
	Low Impact	0-15%	0.31
Light	Regular	16-35%	0.32
	Low Impact	16-35%	0.41
Moderate	Regular	36-65%	0.43
	Low Impact	36-65%	0.53
Heavy		65-85%	0.66
Very Heavy		86%-100%	0.76

Any potential net increase in post-development peak flows would need to be accommodated by the downstream conveyance system. Such an increase in net peak flows would likely require downstream implementation of flow control. In portions of the subarea without established conveyance systems, new conveyance system improvements would likely be needed as development occurs.

3.4.2 Analysis of Potential Impacts

Potential Impacts Common to All Alternatives

Streams, Wetlands, and Related Habitat

Critical areas, such as streams, wetlands, and related habitats are protected natural features by City of Shoreline policy and regulations. Washington State and federal requirements also apply to these natural areas. Potential redevelopment in the station subarea would be required to comply with all applicable local, state, and federal regulations and would undergo detailed analysis and design for specific site conditions.

With any future redevelopment, the proponents would need to complete due diligence and site investigation to support their financing, land use applications, and other permitting. As part of this future work, developers would be required to conduct detailed, site-specific analyses of critical areas and geotechnical conditions. Wetland and stream delineations meeting City of Shoreline, Washington State Department of Ecology, and federal regulations and protocols would be required for all properties undergoing development with wetlands and streams located within the property boundaries or in proximity to the property. Redevelopment applicants would be required to field delineate and survey streams, wetlands, and their buffers as part of their proposals, and the locations of these features would affect the footprint of redevelopment.

In the case of Twin Ponds Park, the wetland system is located within the boundary of the public park property with stream corridors extending outside the park. At Paramount Open Space, wetlands appear to exist both inside public park property and outside the park, on adjacent privately-owned properties. Public park lands would be retained in open space/park use in all future rezoning alternatives.

At this time, it is not known how parcels might be aggregated for future redevelopment, so it is not possible to physically quantify how the critical areas and buffers might affect redevelopment capacity. This would depend on future site specific plans, and each developer would be required to delineate and survey streams, wetlands, and buffers associated with their sites prior to development.

Under Alternative 1—No Action, retaining streams, wetlands, and buffers in the R-6 zoning surrounding Twin Ponds Park and Paramount Open Space would not provide the opportunity to more clearly protect these areas with redevelopment. While there would be fewer people living and working in proximity to the critical areas, this doesn't necessarily mean that the natural areas would not be impacted or degraded if retained in R-6 zoning.

With delineated protection boundaries, buffer averaging, and environmental mitigation, existing critical areas may be further protected and enhanced with future redevelopment under rezoning. Under current zoning, these areas are not clearly delineated and in some cases, residential and backyard structures are currently located in buffers, which would not be allowed with future redevelopment under any of the action alternatives.

Buffer averaging is allowed to improve wetland protection with several conditions. With buffer averaging, the geographic configuration of affected property may change from the buffers approximated as part of the 2015 Wetlands and Streams Assessment. As previously stated, future development/ redevelopment proponents would be required to define, delineate, and survey wetlands and streams as critical areas on their properties as part of their applications to the City of Shoreline. This work also would include identifying classifications of the wetlands and streams and indicating applicable buffer widths for these classifications.

Regardless of the zoning designation, critical areas and associated buffers are protected by City, state, and federal regulations. With future aggregation of properties, even if critical areas and buffers are included within master site plans for development, the streams, wetlands, and buffer requirements would still be applied.

If a developer aggregates a large scale area of property for redevelopment, the buffer areas could be averaged and mitigation may occur through dedicated open space as part of the project. Developers would be required to prepare master site plans indicating their plans to protect streams and wetland and may propose mitigation in accordance with City, state, and federal requirements.

Proposed rezoning alternatives have been created with the intent to have consistent land uses (as well as building heights and densities) within neighborhoods and across rights-of-way. Retaining areas in single family use, while at the same time upzoning immediately adjacent properties, would create some inconsistencies that may not be desirable to property owners.

There is no known research that indicates that mixed use residential or multifamily uses would result in a greater level of impact to nearby streams and wetlands than single family uses. To the contrary, redevelopment can improve the quality of natural areas that are delineated and protected through the permitting process. Stream corridor restoration and wetland enhancements often are implemented as part of these projects. Redevelopment projects are required to comply with stringent local, state, and federal critical areas requirements, as well as stormwater management provisions that control flows and clean water runoff, which improves conditions in surrounding streams and wetlands.

Without redevelopment in the subarea in the vicinity of streams, wetlands, and buffers, large portions of these critical areas would continue to exist within primarily single family lots, rather than be delineated, surveyed, and protected in the redevelopment process. Residential and backyard structures, fertilized lawns and gardens, and other non-natural elements currently located in buffers would remain. With future redevelopment under any of the action alternatives, critical areas boundaries could be more effectively protected. **Figure 3.4-6** illustrates influences on riparian areas in the Thornton Creek Basin (from the Thornton Creek Basin Characterization Report, 2004) and shows the existing extent of homes and lawns along streams in the subarea.

Subsurface and Groundwater Conditions

Where subsurface conditions exist, such as high groundwater and peat deposits, the presence of these conditions is typically addressed through geotechnical analysis and engineering solutions completed on a per project/per site basis. When these conditions are present, land areas can be developed but must implement a variety of engineering and construction techniques suitable to ensure structural stability and protection of existing hydrologic systems.

Liquefaction is a phenomenon where soils experience rapid loss of internal strength as a consequence of seismic activity. Available data and mapping indicate the presence of potentially liquefiable soils in a small portion of the subarea. There are a variety of engineering treatments that address liquefaction, as noted in the Addendum to the DEIS. Because of the variety of mitigation techniques and highly variable ground conditions, site-specific geotechnical engineering investigations must be completed in order to determine the risk of potential liquefaction and cost effective mitigation solutions.

Redevelopment of properties with peat-laden soils, high groundwater, and soils subject to liquefaction and the required engineering treatments and mitigations to address these conditions typically would be more expensive than redevelopment of property without these conditions. However, the presence of these conditions does not typically render properties undevelopable. The redevelopment potential and capacity would depend on many factors, including the amount of land affected by these conditions, the overall configuration and size of the redevelopment parcel (likely aggregated from multiple properties), the type of development (building heights and densities) allowed at the particular property, parking requirements, and other factors.

In many cases, redevelopment projects, especially those of multifamily densities and at larger scales, can afford to off-set the engineering and construction costs associated with these subsurface conditions, as has been evidenced in construction projects throughout the region.

Redevelopment potential is determined on a site-by-site basis, as part of due diligence by property owners. At this time, it is not known how future redevelopment parcels would be configured. As part of future development projects, site-specific subsurface evaluations by licensed geotechnical engineers would need to be completed to determine existing conditions and appropriate design and construction of new development and improvements (buildings, roadways, bridges, utilities, etc.).

Surface Water Management

Private redevelopment and public improvements within the right-of-way (including roadways and pedestrian/bicycle facilities) require stormwater system improvements for collection and conveyance, flow control, and water quality. A variety of stormwater improvements can address these needs, including green stormwater infrastructure and LID treatments, as well as conventional collection and conveyance, storage, and treatment infrastructure.

Development and redevelopment of parcels, per proposed zoning revisions, would require flow control and water quality treatment in compliance with current stormwater regulations, based on the amount of new and replaced impervious surfaces within the improvement site. As stated earlier, the existing development in the subarea was largely completed before extensive stormwater mitigation was required.

For Alternative 1—No Action, redevelopment under current zoning would typically be smaller in scale and less likely to trigger significant flow control mitigation if impervious surfaces do not increase beyond minimum thresholds described later in this section.

This analysis provides a planning-level assessment of the anticipated extent of improvements that would be needed to accommodate growth under each of the action alternatives. The three action alternatives within the subarea would result in redevelopment and change, requiring stormwater utility improvements. Once the rezoning is adopted, each development would be responsible for conducting detailed hydraulic and hydrologic analysis for the proposed changes in land use within the subarea, which would then be used to confirm potential adjustments to the stormwater system.

Since the majority of the publicly-owned surface water collection pipes are reaching the end of their serviceable life, there will be a need for ongoing upgrades and replacements. The City of Shoreline, as the surface water management service provider, regularly conducts systematic condition assessments of the subarea pipes (within the larger Thornton Creek basin) as part of its typical analysis process to support comprehensive planning. Once failing pipes have been identified, necessary replacement projects are listed in the City's Stormwater Pipe Repair and Replacement Program, an ongoing capital improvement program project to repair and replace damaged pipes.

Undersized pipes are typically identified through observation of problematically underperforming pipes as well as hydraulic and hydrologic modeling analyses. In order to adequately convey runoff at the City's targeted level of service, the existing public stormwater conveyance pipes less than or equal to 8" diameter would be closely observed to determine the need for potential upsizing with future development and redevelopment.

Green Stormwater Infrastructure, Low Impact Development, and Subregional Facilities

Redevelopment along streets and within public rights-of-way would bring the opportunity to implement LID such as bioretention swales, stormwater planters, filter systems, rain gardens, pervious pavements, and other features, wherever feasible. Successful integration of these elements would reduce the amount of conventional stormwater infrastructure improvements needed in the subarea. Implementation of a system of subregional surface water management facilities in the subarea could reduce the amount of facilities that need to be constructed on individual redevelopment sites. Benefits associated with subregional facilities are described in more detail under Mitigation Measures.

Future Growth Demand Forecasting

Future growth demand forecasting for surface water infrastructure was based on an estimated percent of impervious surface areas for the projected residential and commercial population forecasting for each zoning alternative. The demand forecasting was used specifically for the DEIS and FEIS analysis for the subarea. Detailed hydraulic modeling would need to be completed in the future as part of updating comprehensive plans/master plans and as part of project development permits to identify the demand and needed improvements for each project and site. The demand was forecast for build-out of each alternative (Alternative 4—Compact Community Hybrid, Alternative 3—Compact Community, Alternative 2—Connecting Corridors, and Alternative 1—No Action).

Demand for Surface Water Management Facilities

Surface water management is not directly impacted by population; however, more development typically produces larger areas of impervious surface, which if *unmitigated* would cause an increase in runoff volumes and peak flows, leading to downstream impacts. Redevelopment projects would be subject to Department of Ecology regulations for flow control and water quality. (Refer to discussion under 3.4.3b later in this section.) Integration of green stormwater infrastructure and LID techniques into redevelopment projects can reduce the demand generated and have other environmental benefits.

Surface water management demand, based on precipitation rates for the 25-year peak storm event discussed previously in this section and percent increase in unmitigated stormwater flows for each zoning alternative is shown in **Table 3.4-6**.

Mitigating Stormwater Runoff Flows

Potential unmitigated stormwater runoff flows have been calculated to inform the analysis in the EIS, but future redevelopment under action alternatives would be required to control and mitigate stormwater flows. Through flow control as a result of compliance with current regulations, excess runoff to Thornton Creek would be minimized compared to existing conditions. Future redevelopment under the action alternatives also would improve water quality and wildlife habitat over existing conditions.

Overall, a net decrease in stormwater runoff would occur as a result of compliance with current regulations, which were not in place when the subarea originally developed.

Due to the application of current regulations, redevelopment within the subarea would decrease surface water runoff rates and improve water quality wherever the development triggers surface water requirements. Analysis of potential new or upsized conveyance systems is based on theoretical *unmitigated* stormwater flow as a percent increase over existing zoning conditions. As discussed earlier in this section of the FEIS, projecting conveyance needs based on *unmitigated* stormwater flows is a conservative method. In addition to on-site mitigation driven by development requirements, downstream implementation of subregional facilities and dispersed LID will reduce the flows below the *unmitigated* estimates.

The changes in impervious area and increased peak runoff for a 25-year, 24-hour storm event are estimated for each action alternative, based on the growth estimates and proposed land uses in traffic analysis zones, aggregated for each drainage subbasin.

Table 3.4-6 shows the total percentage change in increased *unmitigated* runoff in each subbasin for each action alternative. Again, note that the *unmitigated* runoff is an over-estimation since stormwater runoff flows would be controlled and mitigated as required with future development/redevelopment.

Table 3.4-6—*UNMITIGATED* increase in Stormwater Flow, All Alternatives

	ALTERNATIVE 1—NO ACTION	ALTERNATIVE 4—COMPACT COMMUNITY HYBRID	ALTERNATIVE 3—COMPACT COMMUNITY	ALTERNATIVE 2—CONNECTION CORRIDORS
		% Increase from Existing*	% Increase from Existing*	% Increase from Existing*
Meridian Creek Subbasin	Base Condition	0 %	1%	6%
Twin Ponds Subbasin	Base Condition	12%	11%	16%
Littles Creek Subbasin	Base Condition	9%	11%	14%
Hamlin Creek Subbasin	Base Condition	2%	2%	2%

* Estimated overall percent increase (for all TAZs) in conveyance sizing for unmitigated stormwater flows with zoning revisions.

Alternative 1—No Action

Alternative 1—No Action was assumed to have the same surface area as the existing system. Currently, the majority of the subarea is zoned R-6, and would remain so under Alternative 1—No Action. The total projected flow rate for Alternative 1—No Action is considered the base condition of storm water runoff for the peak 25-year, 24-hour event peak runoff flow.

Under Alternative 1—No Action, there would be limited redevelopment requiring green stormwater infrastructure and LID techniques, and because redevelopment and associated stormwater improvements would be minimal, existing drainage issues would continue. Redevelopment following current zoning would be smaller in scale and may not trigger flow control mitigation if impervious surfaces do not increase beyond the thresholds described earlier.

Alternative 4—Compact Community Hybrid

Alternative 4 is projected to create an *unmitigated* increase of surface water flow of zero percent in the Meridian Creek Subbasin, 12 percent in the Twin Ponds Subbasin, nine percent in the Littles Creek Subbasin, and two percent in the Hamlin Creek Subbasin over the baseline existing conditions.

Alternative 3—Compact Community

Alternative 3 would generate increased *unmitigated* flows of one percent in the Meridian Creek Subbasin, 11 percent in the Twin Ponds Subbasin, 11 percent in the Littles Creek Subbasin, and two percent in the Hamlin Creek Subbasin.

Alternative 2— Connecting Corridors

With redevelopment in a more spread out form Alternative 2 would create higher *unmitigated* increases of surface water flows than the other action alternatives with a six percent increase in the Meridian Creek Subbasin, 16 percent in the Twin Ponds Subbasin, 14 percent in the Littles Creek Subbasin, and two percent in the Hamlin Creek Subbasin.

3.4.3 Mitigation Measures

Surface Water Master Plan Actions

A few improvements to services and facilities in the subarea were considered in the 2011 Surface Water Master Plan. Additional improvements to listed services and facilities would be necessary to accommodate future development, depending on which alternative is implemented. An approximate list of improvements necessary for each alternative in relation to stormwater services is provided later in this section of the FEIS. Planned stormwater improvements in the subarea, along with additional recommended improvements to support implementation of the action alternatives (Alternatives 2, 3, or 4) are illustrated in **Figure 3.4-10 and Figure 3.4-11** at the end of this section.

The City's 2011 Surface Water Master Plan made recommendations regarding two relatively isolated drainage issues in the vicinity of the subarea. Both are located within the Littles Creek Subbasin. One recommendation involves improvements to reduce Littles Creek main stem flooding near 14849 12th Avenue NE. There is no CIP project currently programmed to address this issue. The other recommendation involves resolving localized poor drainage due to a disconnected catch basin on NE 148th Street between 12th and 15th Avenues NE. The NE 148th Street Infiltration Facilities CIP, currently in the design phase, will resolve this issue in the near future.

The 2011 Surface Water Master Plan lists a number of other recommended drainage improvements upstream of the subarea, but changes for this subarea would not impact the design of the upstream projects. In general, the capacity of all subarea conveyance systems would need to be further evaluated as future growth progresses.

The 2011 Surface Water Master Plan also recommended multiple projects to improve portions of existing wetland and stream systems within the subarea (such as Thornton Creek near Twin Ponds) that exhibit multiple structural fish-passage barriers and/or invasive plant species encroaching into critical areas. These recommended aquatic improvement projects are not directly linked to the alternatives, but stream or wetland enhancements within the subarea could potentially address some of these existing impacts.

Applicable Regulations and Commitments

Critical Area Code Requirements

Through City of Shoreline Municipal Code, Chapter 20.80 –Critical Areas, the City has identified six critical areas that require protection and development buffers to protect the environmentally critical areas while accommodating the rights of property owners to use their property in a reasonable manner. The six environmentally critical areas are geologic hazard areas, fish and wildlife habitat conservation areas, wetlands, flood hazard areas, streams, and aquifer recharge areas.

Washington State Department of Ecology and City of Shoreline Surface Water Management Requirements

The City of Shoreline Municipal Code, Chapter 13.10 – Surface Water Utility, adopts the most recent version of the Stormwater Management Manual for Western Washington (SWMMWW) published by the Washington State Department of Ecology. This manual requires flow control and water quality treatment for new and redevelopment projects that exceed specific hard surface area thresholds. Water quality mitigation is required for hard surfaces that are considered pollution generation surfaces.

Integration of LID and green stormwater infrastructure into redevelopment projects can help manage stormwater with a similar process to that within natural systems. Bioswales, rain gardens, and other features capture and retain water onsite, allowing time for it to soak into the soil, where it is naturally filtered. This process also captures pollution and improves water quality. LID treatments are encouraged by policies in the City's Comprehensive Plan, as well as in the proposed subarea plan, and are the preferred mitigation element in the SWMMWW.

The City of Shoreline is required through the Western Washington Phase II National Pollutant Discharge Elimination System (NPDES) Permit to control pollutant loads and reduce peak flows from developed sites and municipal facilities within the city. There are five program components pertaining to the NPDES Permit. Components #1, #2, and #3 are Public Education and Outreach, Public Involvement and Participation, and Illicit Discharge Detection and Elimination. These three components would be applicable under any of the alternatives. The extent of implementation of the remaining two components, #4 and #5 as described below, would vary depending on development growth within the subarea.

NPDES Component #4 – Controlling Runoff from New Development, Redevelopment, and Construction Sites

This component requires that the City of Shoreline develop, implement, and enforce a program to reduce pollutants in stormwater runoff from new development, redevelopment, and construction site activities. The NPDES Permit prioritizes LID as the preferred and commonly used approach to site development.

Another major aspect of this component is ongoing maintenance and inspection of surface water facilities. The City is currently meeting this goal by enforcing that private developers maintain their private surface water facilities permitted since 2007. The City of Shoreline inspects several hundred surface water facilities on a rotating inspection cycle to ensure all surface water facilities are functioning as designed.

Additionally, in 2009 the City of Shoreline adopted the Department of Ecology Low Impact Development Manual, which requires that best practices be used unless shown to be infeasible.

NPDES Component #5 – Municipal Operations and Maintenance

This component requires that the City of Shoreline reduce potential impacts to water quality through its operations and maintenance division of public infrastructure. The Roads Division of the City of Shoreline follows guidance from the ESA Regional Road Maintenance Program Guidelines. The Surface Water Division implements a rigorous stormwater system inspection, maintenance, and cleaning program. The Parks Department adopted an Integrated Pest Management Program. Additionally, all City Maintenance Yards operate under a Surface Water Pollution Prevention Plan (SWPPP) and are regularly inspected to assure compliance with the SWPPP.

A major aspect of this component is inspecting all municipally owned and operated catch basins and inlets at least once before August 1, 2017. Additionally, the City of Shoreline is committed to using applicable best management practices (BMPs) associated with runoff control during routine maintenance, and using a Work Order software program to track inspections and maintenance/repair activities.

These two program components are applicable to future development within the subarea, in that future growth would require additional infrastructure, including public and private facilities. Through the NPDES permit, pursuit of LID improvements to help manage and mitigate surface water runoff is encouraged. The conventional (non-LID) approach to managing stormwater runoff has limitations for recovering adequate storage and distributed flow paths necessary to more closely match pre-development hydrologic function and protect aquatic resources from adverse effects of development.

Green stormwater infrastructure and LID principles and applications present a significant conceptual shift from a structural approach to a source reduction approach. LID improvements utilize native soils, vegetation protection areas, and landscaping strategically distributed throughout the project to slow, store, and infiltrate storm flows. LID improvements are designed into the project as amenities, as well as hydrologic controls. Types of LID improvement include vegetated roofs, rainwater harvesting, rain gardens, permeable pavement, and bio-retention swales.

New development within the City of Shoreline will need to conform to regulations within the NPDES Permit and the Ecology

LID Manual provisions of the Development Code. Development will be required to utilize LID improvements to reduce flows, infiltrate where applicable, and treat stormwater before discharging to the City's surface water network. The City is required to monitor these facilities to verify they are working properly, and to maintain LID improvements installed within public right-of-way unless an agreement has been reached with adjacent property owners.

Streams, Wetlands, and Critical Areas

The process of redevelopment can benefit critical areas through planning, design, and implementation of environmental enhancement measures. As part of City's permitting process and related review of site plans and master plans, the City can require specific measures to protect the natural environment as needed on a case by case basis and as prescribed in the Critical Areas section of the SMC. In addition to requirements related to flow control, water quality treatment, and habitat protection at the local, state, and federal levels, other potential measures that the City could require of development projects include:

- Fencing and signage along critical area boundaries (such as split rail fencing)
- Limiting impacts of public access to high value and/or sensitive habitat portions of the parks (by installing fences, boardwalks, etc.).
- Restoration efforts, such as stream daylighting and restoration, wetland enhancement, and native landscaping and removal of invasive plants in stream and wetland buffers.

In addition to improvements that may happen through private development, listed above, public improvements could occur as part of street and park projects. For example, phased implementation of park improvements for stream and wetland protection and enhancement could be implemented as an adaptive management approach as the subarea grows.

Subsurface and Groundwater Conditions

Site-specific subsurface evaluations by a licensed geotechnical engineer should be completed prior to design and construction of new development and other improvements (buildings, roadways, bridges, utilities, etc.). Among other geotechnical considerations, site-specific explorations and evaluations are important in identifying and understanding the depth, extent and nature of groundwater, peat conditions, and other subsurface conditions such as liquefaction in the vicinity of the planned improvements. The following sections include general geotechnical design and construction considerations for sites impacted by the presence of groundwater or peat.

Design and Construction Mitigation Measures

Various design and construction techniques are regularly implemented throughout the region to address groundwater, peat, liquefaction, and other subsurface conditions, as summarized below.

Groundwater Conditions

Groundwater is commonly considered in the design and construction of infrastructure and development projects. The presence and depth of groundwater can be evaluated during site investigations by installing groundwater monitoring wells at locations and depths of interest. Planning by the project team would be required for excavations or drilled foundation elements extending below the perched or static groundwater table.

If temporary or permanent dewatering is required, the site and surrounding areas should be evaluated to determine whether dewatering may result in settlement of compressible soils (including peat) within the dewatering zone of influence. Groundwater flow rates and quantities, and appropriate dewatering systems, can vary significantly based on the porosity of the subsurface soils. Appropriate engineering study and design would be necessary as part of future redevelopment projects to address and prevent potential issues related to ground settlement in the project vicinity that can result from dewatering.

Structures extending below the design groundwater table should be waterproofed and designed to resist hydrostatic uplift pressures.

Peat Conditions

Based on available information, peat deposits are present in the subarea vicinity, and lenses may be encountered, particularly in the vicinity of Twin Ponds. Because peat is a somewhat fibrous material consisting of fragments of decayed organic matter, compressibility characteristics can vary significantly. Peat conditions would need to be evaluated during the site investigation phase with laboratory testing of selected samples. Peat typically undergoes two phases of settlement: relatively short-term primary consolidation and long-term secondary compression. Minimizing load increases from site grading, foundations, or dewatering reduces potential short-term primary consolidation settlement. Long-term settlement of site grades underlain by peat should be expected regardless of whether additional fill is placed.

Several techniques are available for settlement mitigation of structures, roadways and embankments where peat is present. Some of these include:

- **Preloading and/or lightweight fill**—Depending on total and differential settlement tolerances, it may be feasible to use preloading and lightweight fill individually or in combination to reduce settlement of structures, roadways and embankments underlain by peat. Preloading a site, typically with a soil berm, can advance the short and long-term settlement prior to construction. The proportion of total settlement that occurs prior to construction depends on the weight and duration of the preload and the compressibility and drainage characteristics of the underlying soil. Surcharging (adding additional weight on top of the preload), and/or installation of wick drains can accelerate the primary consolidation settlement duration. Lightweight fill consisting of Geofoam or other material can be used to reduce settlement by reducing the net load change on the compressible soil layer.

- **Rigid Inclusions—**Ground improvement consisting of stiff or rigid inclusions may be utilized to reduce total and differential settlement of structures, roadways, and embankments. Settlement reduction would depend on the type of ground improvement used and the improvement replacement ratio. Several ground improvement alternatives are available, including use of aggregate piers (grouted and ungrouted), grouted vertical elements, and vertical elements, such as timber or concrete piles.

- **Deep foundation support**—Structural loads may be transferred through deep foundation elements to competent layers underlying the compressible peat. Deep foundation support alternatives include driven piles, drilled shafts, augercast piles, among others, each of which have unique design and construction considerations. When structural loads are supported with deep foundations, long-term settlement of adjacent and connecting utilities and other improvements must be considered and accounted for in the design by such means as affixing below-slab utilities to the slab, and providing flexible connections between pile supported and non-pile supported elements.

- **Removal and replacement of peat with structural fill**—This approach may be cost-effective depending on the depth and volume of peat to be removed below the project site. Removal and replacement eliminates settlement concerns for the planned structures constructed above, and reduces the risk of potential differential settlement between structures (including roads or utilities) supported by deep foundations or by other ground improvement methods.

Considerations must also be made for utilities underlain by peat. Settlement-sensitive utilities, such as gravity sewers or storm drains, should be designed with adequate grade to accommodate estimated long-term settlement, or designed to mitigate settlement using one of the approaches described above.
As peat decomposes over time, it generates methane vapors. Structures with enclosed space should be designed with provisions to mitigate methane vapor. Common methods include installation of methane barriers below floor slabs and/or methane collection pipes installed within a gravel layer below the slab and vented outside of the building.

Liquefaction

Potential mitigation measures for liquefaction can vary based on the level of risk at each site, as well as the actual subsurface conditions and planned site improvements. Mitigation measures may include, but are not limited to (1) ground improvement techniques such as vibro compaction, vibro replacement (e.g. stone columns), aggregate piers (e.g. Geopiers), soil mixing or compaction grouting, or (2) the support of structures on deep foundations designed to resist liquefaction-induced settlement and lateral movement. Because of the variety of mitigation techniques and highly variable ground conditions in the city, site-specific geotechnical engineering investigations must be completed in order to determine the risk of potential liquefaction and cost effective mitigation solutions.

All development projects are required to design buildings in accordance with the International Building Code, which addresses seismic as well as structural, public safety and security, accessibility, fire protection, and other requirements.

Potential Stormwater Infrastructure Improvement Needs

With development and redevelopment of any of the action alternatives in the subarea, many streets would be improved to accommodate higher volumes of vehicles and pedestrians. A more urban street network would emerge over time. As streets are improved, many of the ditches and sheet flow dispersion areas would be converted to curb, gutter, and sidewalk, requiring installation of new or upsized conveyance systems with detention and treatment facilities. The conveyance systems may be bioretention swales or enclosed pipe networks, or a combination of these.

Dispersed LID facilities should be implemented to the extent feasible within the subarea. Many of the existing streets currently contain ditches and swales at the edges of the roadway. When new developments are constructed within the subarea, many of the streets would be improved to accommodate the added influx of users. When this occurs, many of the open ditches could be converted to green infrastructure/LID features.

Due to the limited growth projected under the No Action Alternative, significant public infrastructure improvements, including implementation of LID treatments retrofitted into roadway rights-of-way, would not be anticipated. Infrastructure improvements as required by aging, failed, and otherwise inadequate existing drainage systems would be required over time but are omitted from this assessment exercise as being driven by a separate set of issues.

Table 3.4-7 contains a list of surface water conveyance improvements projected to manage future runoff and the increased impervious surface associated with development of each alternative. **Figure 3.4-11** depicts these planned and recommended improvements geographically. Locations that would require potential upsizing of the existing conveyance systems are based on *unmitigated* stormwater flow comparisons between the planned action alternatives and current zoning. Increased pipe or swale capacity would primarily be required in locations where runoff is conveyed to a potential downstream subregional flow control facility.

New conveyance systems are identified for locations of the subarea that do not have established conveyance systems under existing conditions or areas where improved pedestrian facilities would likely impact the current drainage flow paths.

Table 3.4-7—Potential Surface Water Conveyance Improvements

Alternative	New Conveyance (LF)	Upsized Existing Conveyance (LF)	Improved Conveyance Totals (LF)
#4 — Compact Community Hybrid	8,450	14,500	22,950
#3 — Compact Community	8,450	13,000	21,450
#2 — Connecting Corridors	8,950	14,850	23,800
#1 — No Action	0	0	0

Alternative 1—No Action

Since Alternative 1—No Action would contain the same zoning as under existing conditions, no additional conveyance improvements are projected within the subarea. The creation of new households or infill redevelopment could occur under Alternative 1—No Action. However, this redevelopment likely would continue to be served by the existing system. New sites and households would be required to manage stormwater related to individual redevelopment when mitigation thresholds are triggered, but capital improvements at a larger scale would not be anticipated. Also under the No Action Alternative, pipe replacement would still occur as the service life of the existing stormwater infrastructure is reached. Per the City's 2011 Surface Water Master Plan update, the replacement of pipes is either as facilities fail or through an opportunistic replacement as other roadway or improvement projects are completed adjacent to the required pipe upgrades.

Twenty Year Improvements with or without Phasing

The twenty year projection for growth anticipates 11,207 to 13,635 population, 4,670 to 5,681 housing units, and 2,180 to 2,678 jobs/employees within the subarea by 2035. This projection is based on an average annual growth rate in the range of 1.5 percent to 2.5 percent.

If specific Phase 1/Phase 2 boundaries are adopted, growth under any of the action alternatives through 2033 would be limited to within the Phase 1 geographic area. For Alternative 4—Compact Community Hybrid, the Phase 1 area would accommodate space for 10,736 housing units and 8,787 jobs/employees. Alternative 3—Compact Community would have space for 13,676 housing units and 8,746 jobs/employees, and Alternative 2—Connecting Corridors would have space for 10,468 housing units and 8,363 jobs/employees within the Phase 1 boundaries. Projected Phase 1 surface water improvement needs are listed below.

Alternative 2 – Connecting Corridors would impact the largest surface area, where moderate to high density mixed use and multifamily redevelopment would necessitate surface water improvements. For Alternative 2—Connecting Corridors, the total estimated length of conveyance improvements that would be necessary to accommodate the projected Phase 1 population is approximately 6,200 feet. This estimate would implement a combination of conveyance upgrades (listed above for each alternative) as well as new improvements. New conveyance improvements to serve Alternative 2 likely would include:

a. 1,350 feet along 8th Avenue NE from NE 155th Street to NE 150th Street
b. 1,800 feet along 6th Avenue NE from NE 152nd Street to NE 145th Street
c. 550 feet along NE 151st Street from 8th Avenue NE to 10th Avenue NE
d. 300 feet along NE 145th Street from 6th Avenue NE to 5th Avenue NE

12” diameter or larger pipes or bioretention swales may be necessary as well. Alternative 4 would require about 15 percent less conveyance improvements than Alternative 2, and

Alternative 3 would require about 20 percent less and Alternative 4 about 15 percent less improvements than Alternative 2 within the Phase 1 boundary. However, locations of improvements would likely be similar to those listed above.

Without specific Phase 1/Phase 2 boundaries, additional conveyance pipe runs likely would be needed to accommodate the projected population in 2035 over a broader geographic region. 12” diameter or larger pipes or bioretention swales may be necessary in the following areas:

a. 1,350 feet along 8th Avenue NE from NE 155th Street to NE 150th Street

b. 1,800 feet along 6th Avenue NE from NE 152nd Street to NE 145th Street
c. 2,200 feet along 12th Avenue NE from NE 148th Street to NE 145th Street, and along NE 145th Street to 17th Avenue NE
d. 550 feet along NE 151st Street from 8th Avenue NE to 10th Avenue NE
e. 300 feet along NE 145th Street from 6th Avenue NE to 5th Avenue NE

Alternative 4—Compact Community Hybrid

Alternative 4 is similar to Alternative 3 with added rezoning of along N/NE 155th Street (similar to Alternative 2), but with less rezoning around the parks in the subarea.

Approximately 22,250 feet of new and/or upsized conveyance systems may be needed to handle projected surface water runoff from future development.

The following ***existing*** pipes and/or ditch systems may need capacity improvements in the form of new bioretention swales and/or pipe networks to accommodate the increase in impervious surfaces under total build-out of Alternative 4:

a. 600 feet along N 155th Street, from 3rd Avenue NE to 5th Avenue NE.
b. 500 feet along 5th Avenue NE, from N 157th Street to N 155th Street.
c. 400 feet along N 155th Street, from 12th Avenue NE to 15th Avenue NE.
d. 450 feet along N 150th Street from Meridian Avenue N to Corliss Avenue N
e. 900 feet along Corliss Avenue N from N 150th Street to N 147th Street
f. 600 feet along N 149th Street from Corliss Avenue N to 1st Avenue NE
g. 600 feet along N 148th Street from Street from Corliss Avenue N to 1st Avenue NE
h. 800 feet along 3rd Avenue Ne from NE 151st Street to NE 153rd Street
i. 400 feet along NE 151st Street from 3rd Avenue
j. 2,050 feet along 5th Avenue NE from NE 155th Street to NE 145th Street
k. 1,450 feet along 5th Avenue NE from NE 160th St to NE 155th Street
l. 1,100 feet along 12th Avenue S south from NE 155th Street to NE 150th Street
m. 850 feet along N 152nd Street east from 11th Avenue NE to 13th Avenue NE
n. 1,200 feet along 8th Avenue NE from NE 150th Street to NE 147th Street
o. 650 feet along NE 147th Street east from 8th Avenue NE to 10th Avenue NE
p. 400 feet along 146th feet from 9th Avenue NE to 9th Place NE500 feet along NE 155th Street from Wallingford Avenue NE to Meridian Avenue NE
q. 400 feet along NE 150th Street from Meridian Avenue NE to Corliss Avenue NE
r. 300 feet along NE 155th Street from 14th Avenue NE to 12th Avenue NE
s. 650 feet along 5th Avenue NE, from NE 160 Street to NE 145th Street used for private connections, assuming 50 feet per connection

The following ***new*** conveyance systems as bioretention swales and/or new pipe networks may need to be constructed to accommodate the increase in impervious surfaces under total build-out of Alternative 4:

a. 300 feet along NE 154th Street (Private Drive) from 3rd Avenue NE to 5th Avenue NE
b. 600 feet along NE 149th Street from 3rd Avenue NE to 5th Avenue NE
c. 900 feet along 6th Avenue NE from NE 155th Street to NE 152nd Street
d. 1,350 feet along 8th Avenue NE from NE 155th Street to NE 150th Street
e. 550 feet along NE 151st Street from 8th Avenue NE to 10th Avenue NE
f. 950 feet along NE 151st Street from 8th Avenue NE to 10th Avenue NE and along 10th Avenue NE to an existing outfall into Paramount Park
g. 2,200 feet along 12th Avenue NE from NE 148th Street to NE 145th Street, and along NE 145th Street to 17th Avenue NE
h. 1,800 feet along 6th Avenue NE from NE 152nd Street to NE 145th Street
i. 300 feet along NE 145th Street from 6th Avenue NE to 5th Avenue NE

Alternative 3—Compact Community

Approximately 21,450 feet of new and/or upsized conveyance systems may be needed to handle projected surface water runoff from future development.

The following ***existing*** pipes and/or ditch systems may need capacity improvements in the form of new bioretention swales and/or pipe networks to accommodate the increase in impervious surfaces under total build-out of Alternative 3:

a. 450 feet along N 150th Street from Meridian Avenue N to Corliss Avenue N
b. 900 feet along Corliss Avenue N from N 150th Street to N 147th Street
c. 600 feet along N 149th Street from Corliss Avenue N to 1st Avenue NE
d. 600 feet along N 148th Street from Street from Corliss Avenue N to 1st Avenue NE
e. 800 feet along 3rd Avenue Ne from NE 151st Street to NE 153rd Street
f. 400 feet along NE 151st Street from 3rd Avenue
g. 2,050 feet along 5th Avenue NE from NE 155th Street to NE 145th Street
h. 1,450 feet along 5th Avenue NE from NE 160th St to NE 155th Street
i. 1,100 feet along 12th Avenue S south from NE 155th Street to NE 150th Street
j. 850 feet along N 152nd Street east from 11th Avenue NE to 13th Avenue NE
k. 1,200 feet along 8th Avenue NE from NE 150th Street to NE 147th Street
l. 650 feet along NE 147th Street east from 8th Avenue NE to 10th Avenue NE
m. 400 feet along 146th feet from 9th Avenue NE to 9th Place NE
n. 650 feet along 5th Avenue NE, from NE 160 Street to NE 145th Street used for private connections, assuming 50 feet per connection
o. 300 feet along NE 154th Street (Private Drive) from 3rd Avenue NE to 5th Avenue NE

p. 600 feet along NE 149th Street from 3rd Avenue NE to 5th Avenue NE

The following ***new*** conveyance systems as bioretention swales and/or new pipe networks may need to be constructed to accommodate the increase in impervious surfaces under total build-out of Alternative 3:

a. 900 feet along 6th Avenue NE from NE 155th Street to NE 152nd Street
b. 1,350 feet along 8th Avenue NE from NE 155th Street to NE 150th Street
c. 550 feet along NE 152nd Street from 3rd Avenue NE to 5th Avenue NE
d. 950 feet along NE 152nd Street from 8th Avenue NE to 10th Avenue NE and along 10th Avenue NE to an existing outfall into Paramount Park
e. 2,200 feet along 12th Avenue NE from NE 148th Street to NE 145th Street, and along NE 145th Street to 17th Avenue NE
f. 1,800 feet along 6th Avenue NE from NE 152nd Street to NE 145th Street
g. 400 feet along NE151st Street from 3rd Avenue to 5th Avenue NE
h. 300 feet along NE 145th Street from 6th Avenue NE to 5th Avenue NE

Alternative 2—Connecting Corridors

Under Alternative 2, 23,300 feet of new and/or upsized conveyance systems may be needed to handle projected surface water runoff from future development.

The following ***existing*** pipes and/or ditch systems may need capacity improvements in the form of new bioretention swales and/or pipe networks to accommodate the increase in impervious surfaces under total build-out of Alternative 2:

a. 450 feet along N 150th Street from Meridian Avenue N to Corliss Avenue N
b. 900 feet along Corliss Avenue N from N 150th Street to N 147th Street
c. 600 feet along N 149th Street from Corliss Avenue N to 1st Avenue NE
d. 600 feet along N 148th Street from Street from Corliss Avenue N to 1st Avenue NE
e. 800 feet along 3rd Avenue Ne from NE 151st Street to NE 153rd Street
f. 400 feet along NE 151st Street from 3rd Avenue
g. 2,050 feet along 5th Avenue NE from NE 155th Street to NE 145th Street
h. 1,450 feet along 5th Avenue NE from NE 160th St to NE 155th Street
i. 1,100 feet along 12th Avenue S south from NE 155th Street to NE 150th Street
j. 850 feet along N 152nd Street east from 11th Avenue NE to 13th Avenue NE
k. 1,200 feet along 8th Avenue NE from NE 150th Street to NE 147th Street
l. 650 feet along NE 147th Street east from 8th Avenue NE to 10th Avenue NE
m. 400 feet along 146th feet from 9th Avenue NE to 9th Place NE500 feet along NE 155th Street from Wallingford Avenue NE to Meridian Avenue NE
n. 600 feet along N 155th Street from Twin Ponds Park to Wallingford Avenue N

o. 500 feet along N 154th Street from Twin Ponds Park to Meridian Avenue N
p. 450 feet along N 153rd Street from Twin Ponds Park to Meridian Avenue N
q. 400 feet along NE 150th Street from Meridian Avenue NE to Corliss Avenue NE
r. 300 feet along NE 155th Street from 14th Avenue NE to 12th Avenue NE
s. 650 feet along 5th Avenue NE, from NE 160 Street to NE 145th Street used for private connections, assuming 50 feet per connection

The following ***new*** conveyance systems as bioretention swales and/or new pipe networks may need to be constructed to accommodate the increase in impervious surfaces under total build-out of Alternative 2:

j. 300 feet along NE 154th Street (Private Drive) from 3rd Avenue NE to 5th Avenue NE
k. 600 feet along NE 149th Street from 3rd Avenue NE to 5th Avenue NE
l. 900 feet along 6th Avenue NE from NE 155th Street to NE 152nd Street
m. 1,350 feet along 8th Avenue NE from NE 155th Street to NE 150th Street
n. 550 feet along NE 151st Street from 8th Avenue NE to 10th Avenue NE
o. 950 feet along NE 151st Street from 8th Avenue NE to 10th Avenue NE and along 10th Avenue NE to an existing outfall into Paramount Park
p. 2,200 feet along 12th Avenue NE from NE 148th Street to NE 145th Street, and along NE 145th Street to 17th Avenue NE
q. 1,800 feet along 6th Avenue NE from NE 152nd Street to NE 145th Street
r. 300 feet along NE 145th Street from 6th Avenue NE to 5th Avenue NE

Potential Regional or Subregional Stormwater Facility Implementation

Under any of the action alternatives, there could be an opportunity to implement a regional or subregional stormwater facility project that would serve future growth. A subregional facility could provide mitigation for a smaller area, two to three blocks of redevelopment, with a regional system targeting a larger drainage area.

Development of the subarea could include construction of centralized stormwater facilities funded through grants and capital improvement project (CIP) planning and budget. Providing centralized facilities can help to catalyze redevelopment by reducing costs of stormwater infrastructure improvements to individual site development and increase the area of developable land on parcels.

Similar centralized stormwater facilities have been implemented by other local municipalities, including in the vicinity of the proposed light rail station within the Overlake Village Neighborhood of Redmond and are envisioned as a potential method for handling stormwater within the Aurora Square/Shoreline Place Community Renewal Area. Centralized facilities could provide both flow control and water quality mitigation, or the water quality treatment could be implemented through water quality facilities and/or dispersed LID systems.

Implementation of LID and green stormwater infrastructure solutions as part of public right-of-way improvements and onsite development would have a beneficial effect in reducing impacts in the subarea by enhancing stormwater treatment and management. These dispersed facilities would also decrease the potential size of a downstream regional or subregional facility.

Potential regional or subregional stormwater facility locations are preferably sited at locations downstream of anticipated development to provide the maximum benefit for the targeted area. However, stormwater mitigation through an area substitution process can be implemented for drainage areas that would be difficult to directly capture due to topography or available facility locations. These stormwater facilities would preferably be implemented within each subbasin for which significant redevelopment is anticipated. Centralized facilities could be collocated within a park, within the parking lot of a larger commercial or mixed use residential parcel, and various other locations. Locations adjacent to existing or proposed conveyance collection mains would allow water to be directed to the facility with limited new conveyance infrastructure.

Collocation of stormwater facilities within existing or expanded parks or new public plazas would require coordination with the City of Shoreline Parks, Recreation, and Cultural Services (PRCS) Department. Collocation of a stormwater facility within Paramount Open Space may be possible pending critical area requirements and long-term community goals for the park. Partnering with Sound Transit to enlarge the proposed stormwater facility at the 145th Street Station could also be explored as a subregional stormwater facility alternative. The proposed Sound Transit facility could potentially maximize the use of the site as a stormwater vault with a plaza area located above.

Within the Twin Ponds subbasin there are several potential locations for a regional stormwater facility. A facility could be collocated within Twin Ponds Park or on one of the larger mixed use residential sites located adjacent to existing stormwater conveyance mains on 1st Avenue N or Meridian Avenue N (although only a small portion of the subarea drains to the Meridian Avenue N conveyance system).

For the Littles Creek subbasin, a parking lot for the larger mixed use residential or community business parcels along 15th Avenue NE could be used for a regional stormwater facility. The stormwater pipe along 15th Avenue NE provides conveyance for a significant upstream area.

Potential Stream Daylighting

There are a few locations within the subarea where the existing streams are still in piped conveyance systems that provide a barrier to fish passage. Daylighting opportunities for the streams within the subarea are not anticipated within the City's current CIP planning and budget, but there may be future opportunities to daylight as the subarea is redeveloped. Potential daylighting projects would likely require partnering with other agencies or could be explored through park improvements at sites where streams are located.

As described in the Thornton Creek Basin Plan, there are also a number of fish passage barriers along Thornton Creek that are downstream of the subarea and outside of the Shoreline city limits. As Thornton Creek crosses under I-5, the creek is piped for approximately 1,950 feet. A potential new alignment along the west side of I-5 parallel to the southbound exit to NE 145th Street could reduce the length of this pipe crossing. This improvement would require coordination with the Washington Department of Transportation (WSDOT) and adjacent property owners. Funding for a large-scale daylight project at this location is not currently available, but could be explored as a partnering opportunity with WSDOT or Sound Transit and/or through grant funding opportunities.

There appears to be limited area along Meridian Creek with potential for daylighting pipe sections to an open channel system. Some of these isolated areas would require acquisition of additional public land.

Littles Creek is within a piped conveyance system through its entire upper reach to the open channel south of NE 152nd Street that flows into Paramount Open Space. To daylight Littles Creek upstream of NE 152nd Street would likely require acquisition of private land adjacent to 12th Avenue NE or between NE 155th Street and NE 158th Street.

Hamlin Creek is characterized as an intermittent stream in the 2011 Surface Water Master Plan, and as such, environmental benefits through daylighting improvements likely would be more limited.

The Green Network

A concept proposed under any of the action alternatives calls for creation of a "Green Network" of pedestrian paths/sidewalks, trails, bicycle lanes, parks, stream corridors, wetlands, and natural areas throughout the subarea. This Green Network concept would be implemented over time, with pieces constructed as part of redevelopment or as a result of capital projects. Green infrastructure and LID stormwater management and water quality treatment facilities would be part of this network. An illustration of The Green Network concept plan is provided as **Figure 3.4-12** at the end of this section of the FEIS. Refer to photos of potential Green Network features, including green stormwater infrastructure and LID elements, at the end of Section 3.5 of this FEIS.

3.4.4 Significant Unavoidable Adverse Impacts

Growth and change would be expected to occur gradually over many decades under any of the three action alternatives (Alternative 4, 3, or 2). Implementation of full build-out would likely take many years. With application of the capital improvement projects discussed, along with regulatory requirements, no significant unavoidable adverse impacts would be anticipated related to surface water management.

Redevelopment and population growth in the subarea as a result of any of the three action alternatives potentially could have positive and negative effects on streams and wetlands and related habitat. Positive effects would include the potential to clearly delineate and protect streams, wetlands, and their buffer areas with redevelopment, as well as a range of environmental benefits as a result of enhancement and mitigation. Potential negative effects would be mitigated by compliance with critical areas requirements and other regulations at the local, state, and federal level, as well as various mitigation measures.

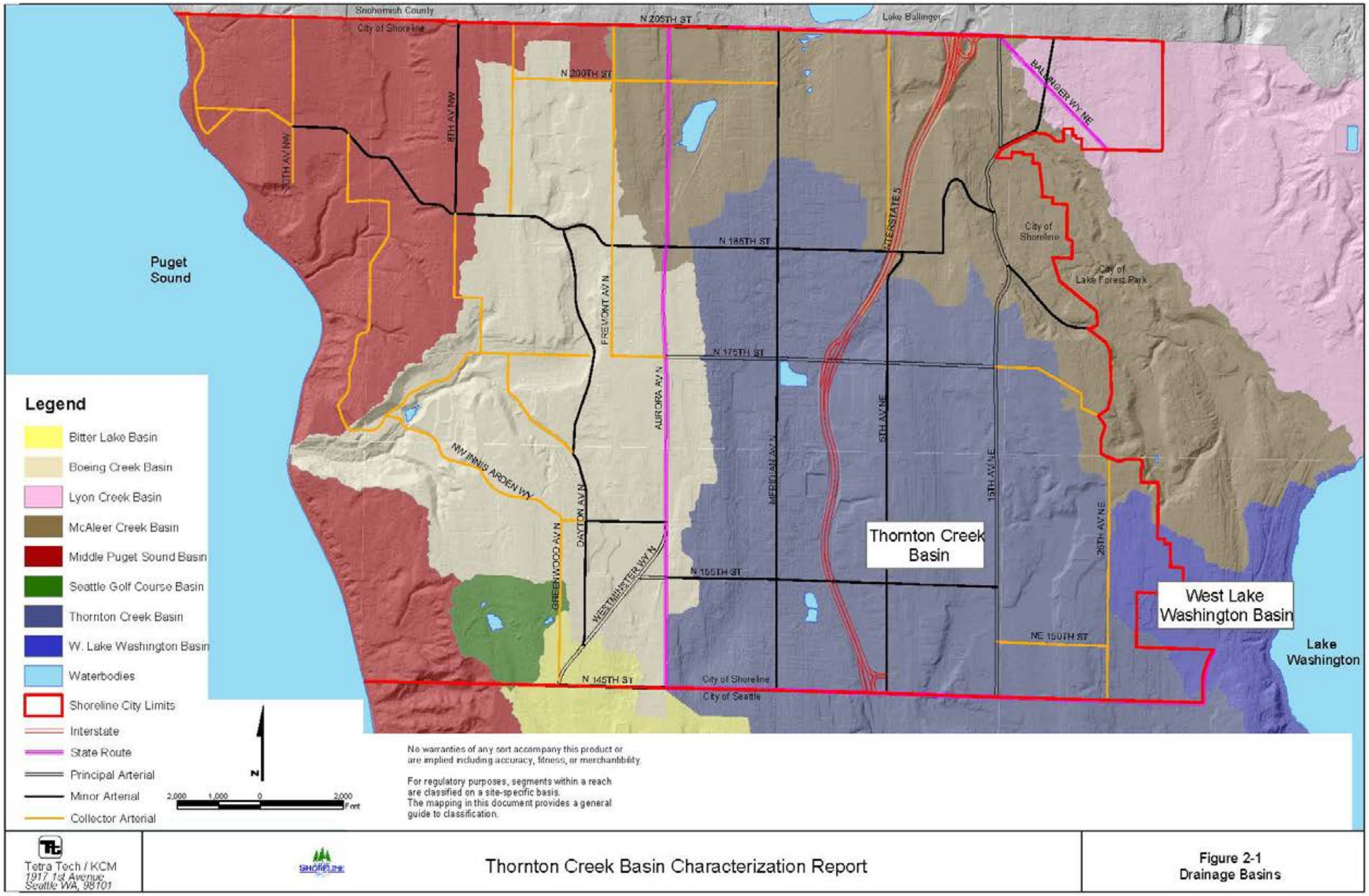


Figure 3.4-1 Thornton Creek Basin and Other Drainage Basins in the Subarea Vicinity (Source: Thornton Creek Basin Characterization Report, 2004)

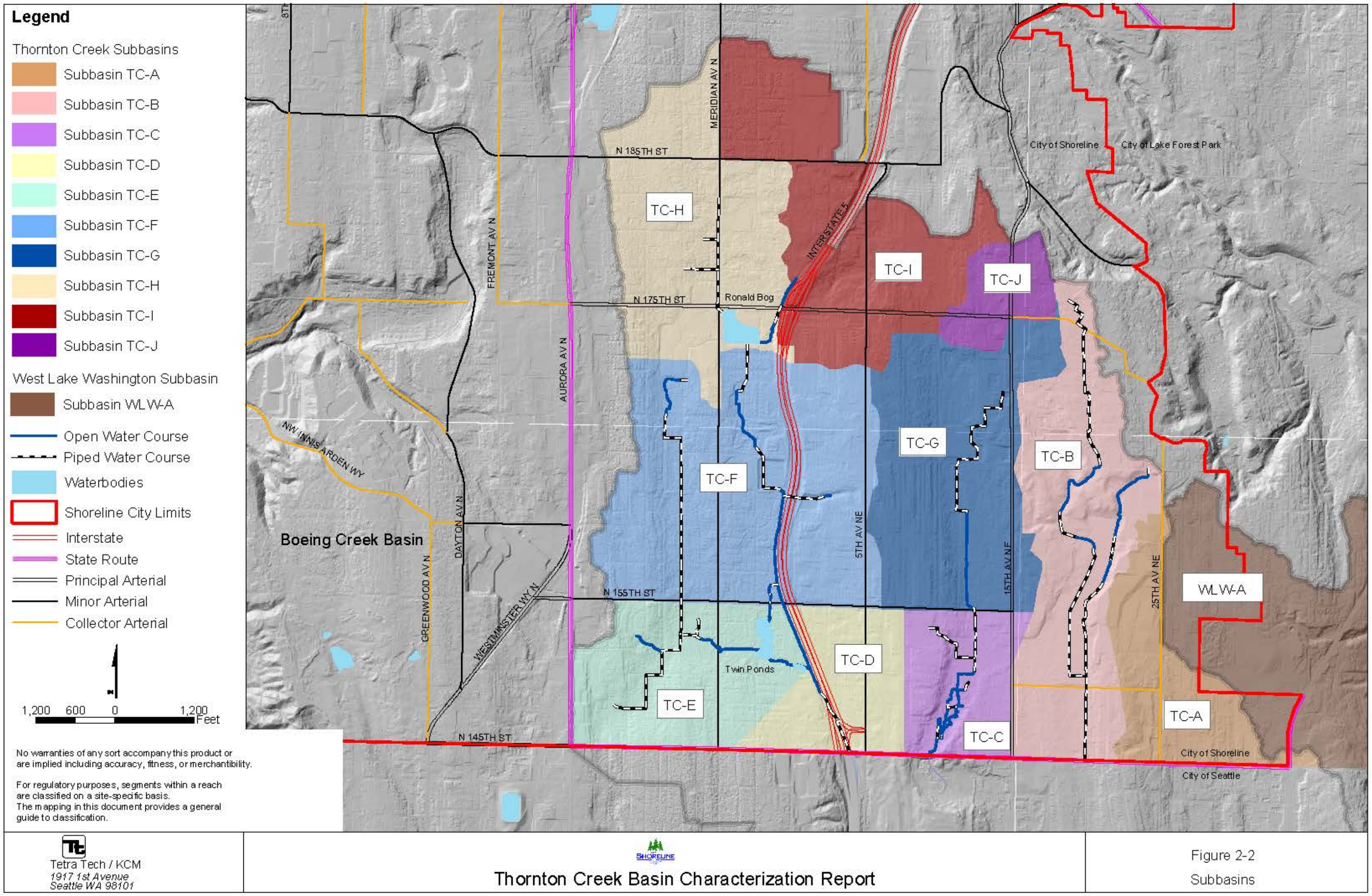


Figure 3.4-2 Subbasins in the Thornton Creek Basin (Source: Thornton Creek Basin Characterization Report, 2004)

Note: Subbasin boundaries differ somewhat from more recent mapping and characterizations by the City of Shoreline, but generally TC-F is in the vicinity of the Meridian Creek Subbasin; TC-E is in the vicinity of the Twin Ponds Subbasin; TC-D and TC-C are in the vicinity of the Littles Creek Subbasin; and TC-B is in the vicinity of the Hamlin Creek Subbasin.

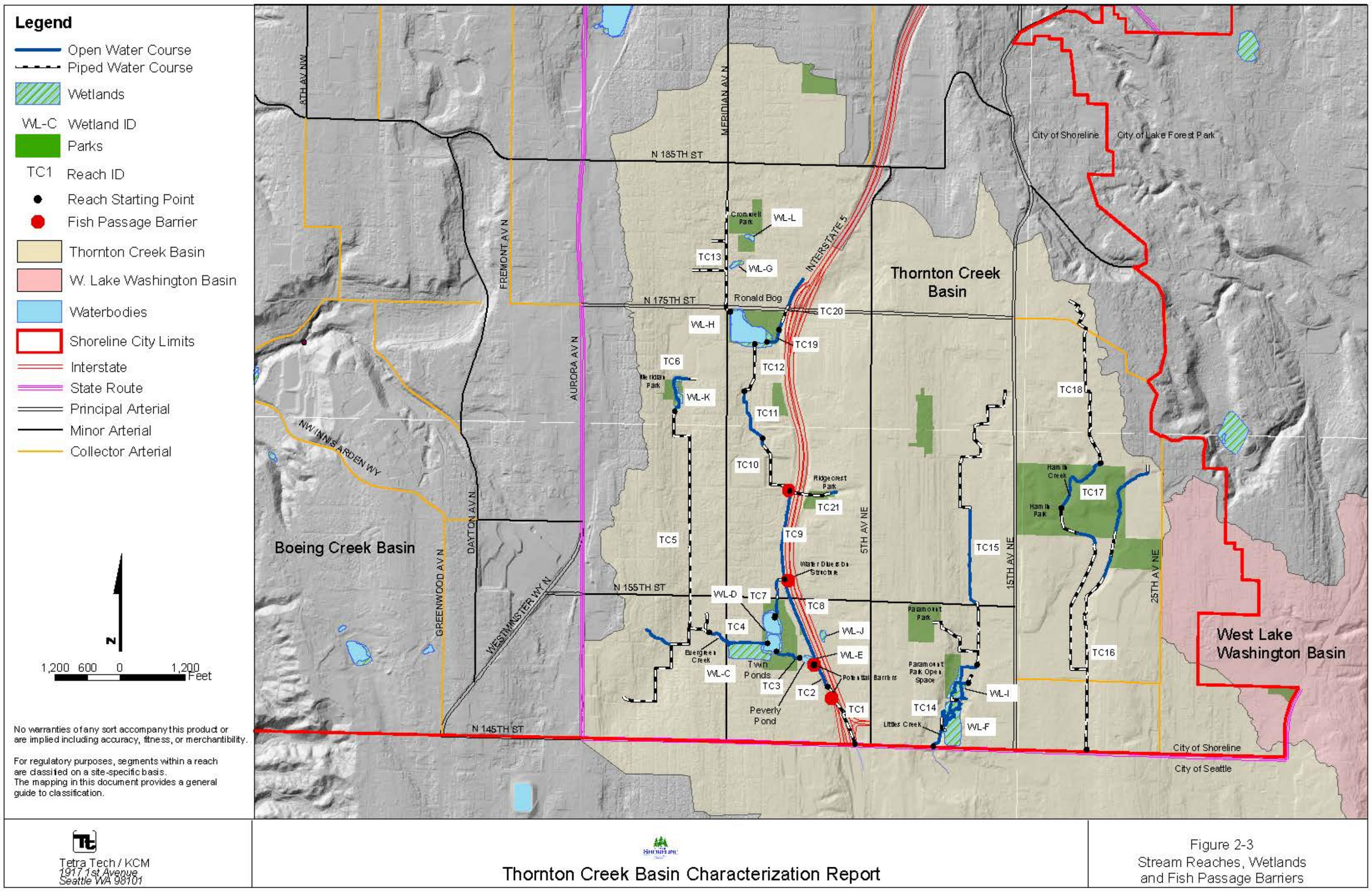
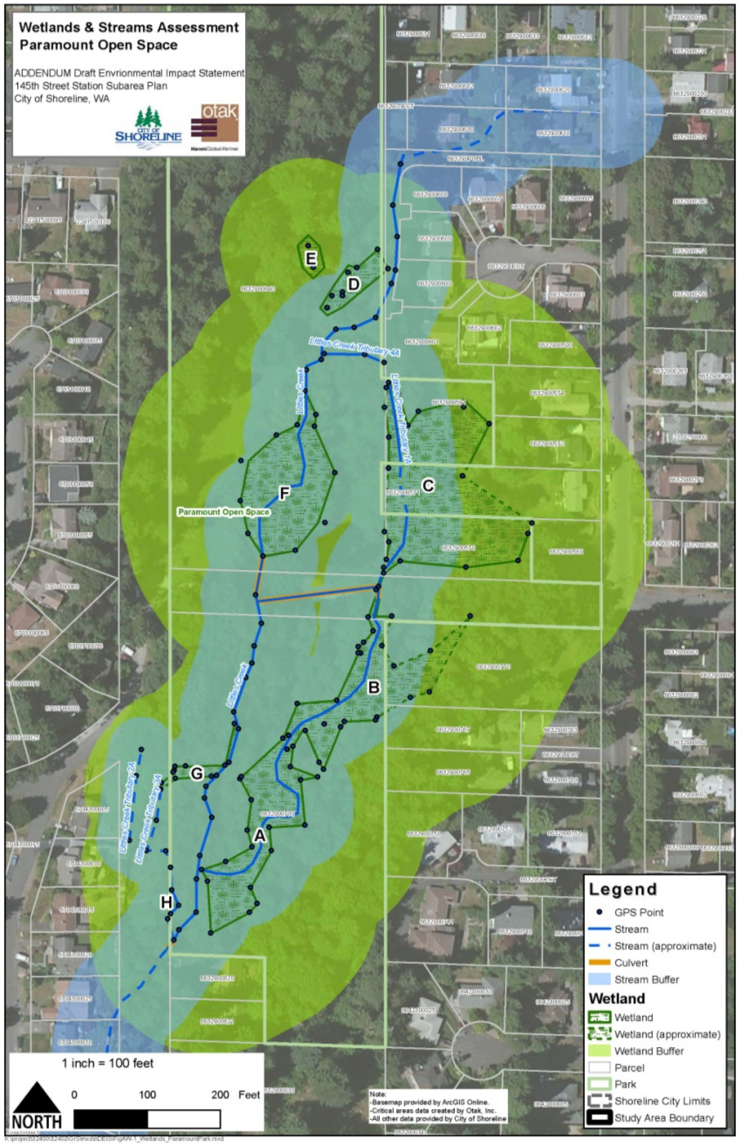


Figure 3.4-3 Stream Reaches, Wetlands, and Fish Passage Barriers in the Thornton Creek Basin (Source: Thornton Creek Basin Characterization Report, 2004)



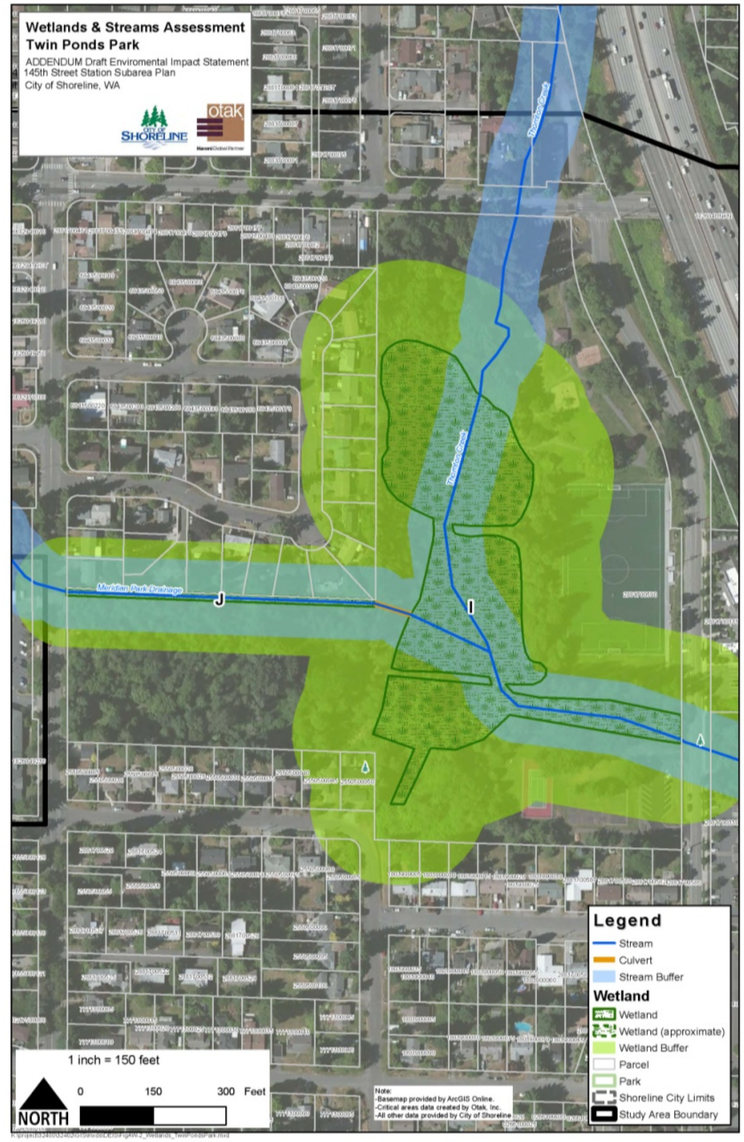


Figure 3.4-4 Paramount Open Space and Figure 3.4-5 Twin Ponds Park—Preliminary, GIS-Based Mapping from the 2015 Reconnaissance and Assessment

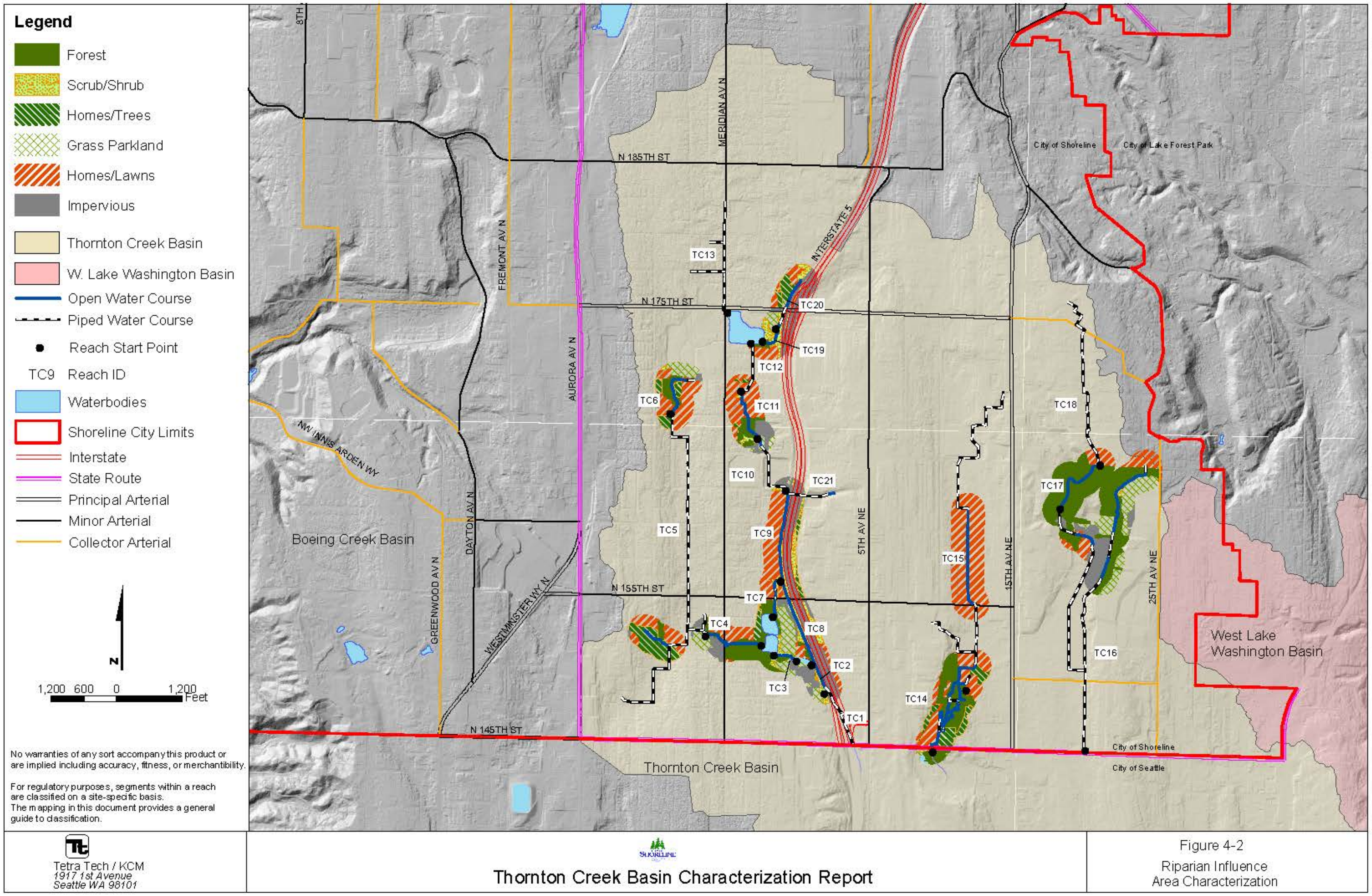


Figure 3.4-6 Riparian Influence Area Mapping (Source: Thornton Creek Basin Characterization Report, 2004)

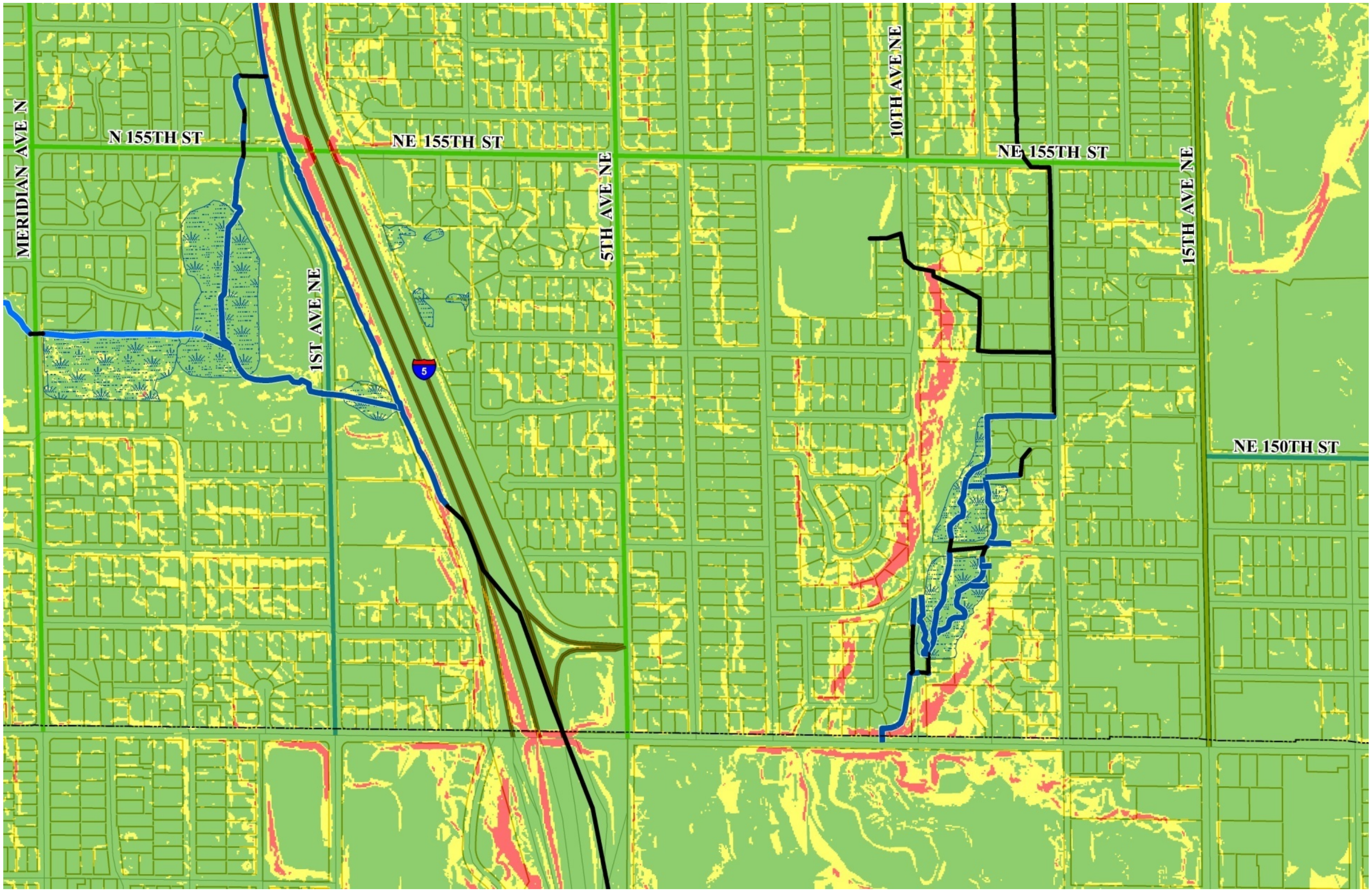


Figure 3.4-7 City of Shoreline Critical Areas Mapping for the Subarea Vicinity

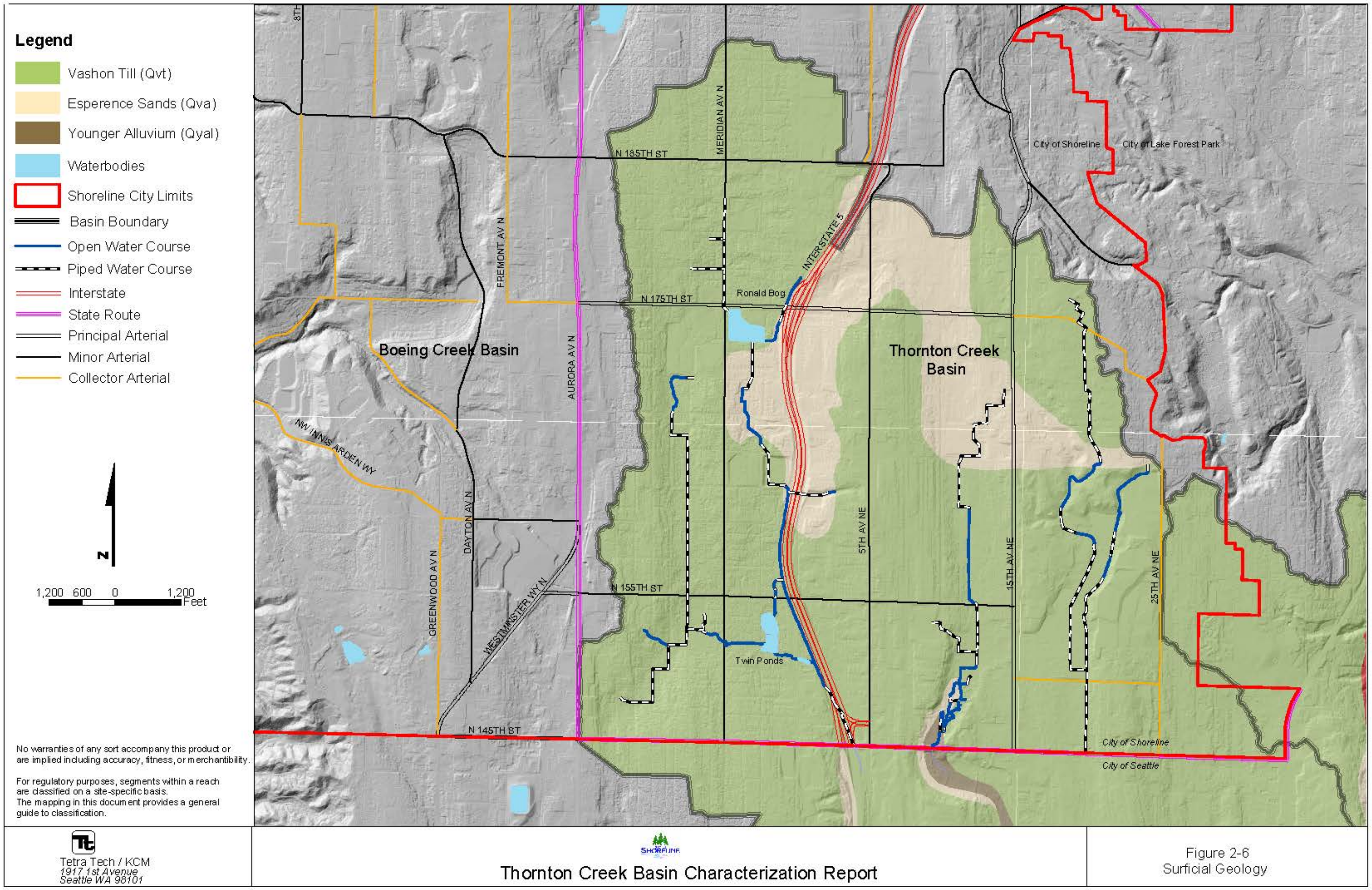


Figure 3.4-8 Surficial Geology Mapping (Source: Thornton Creek Basin Characterization Report, 2004)

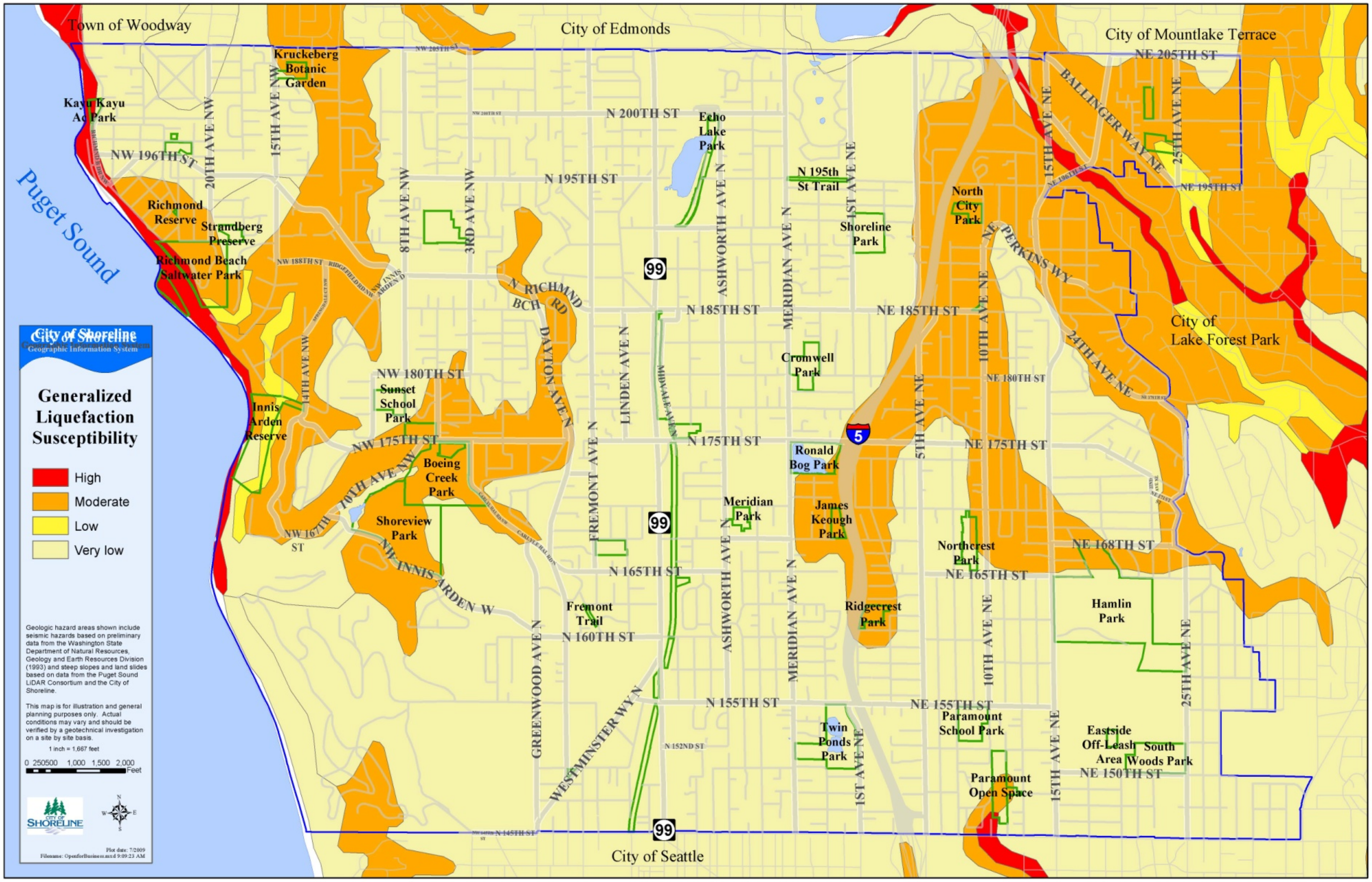


Figure 3.4-9 Potential Liquefaction Areas (Source: City of Shoreline)

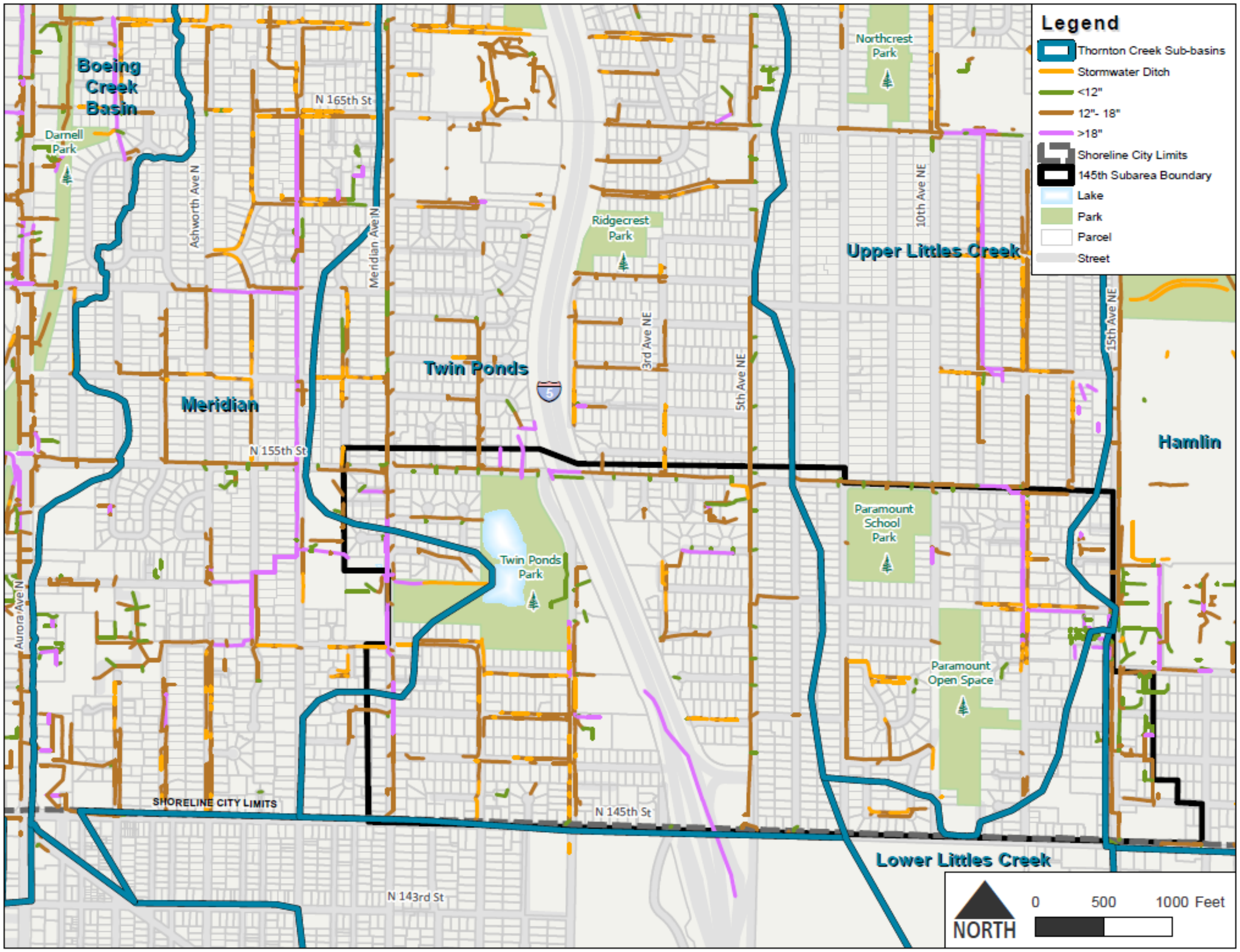


Figure 3.4-10 Existing Drainage Sub-basins and Surface Water/Stormwater Facilities in the Subarea

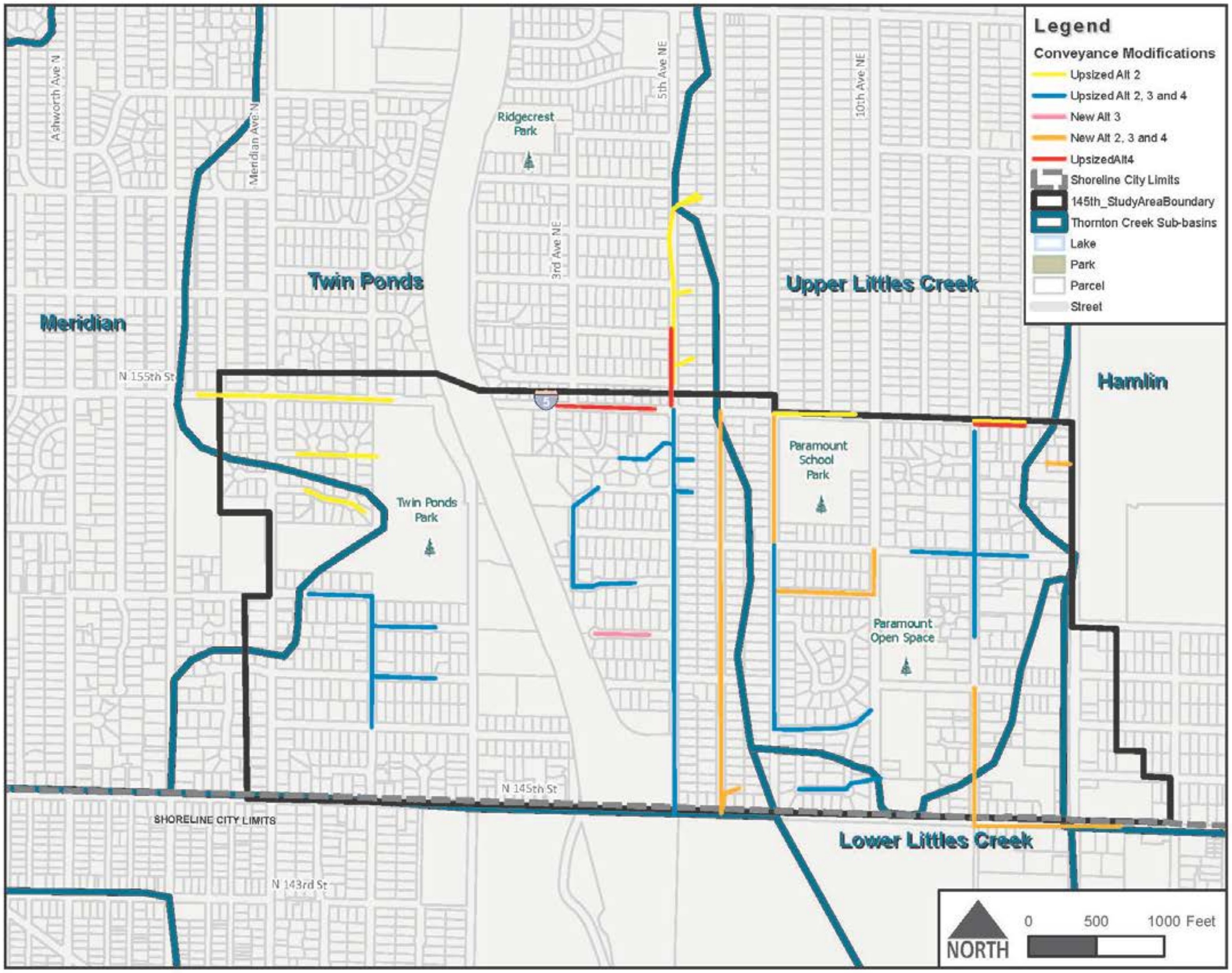


Figure 3.4-11 Planned and Recommended Surface Water/Storm Drainage Improvements in the Vicinity of the Subarea

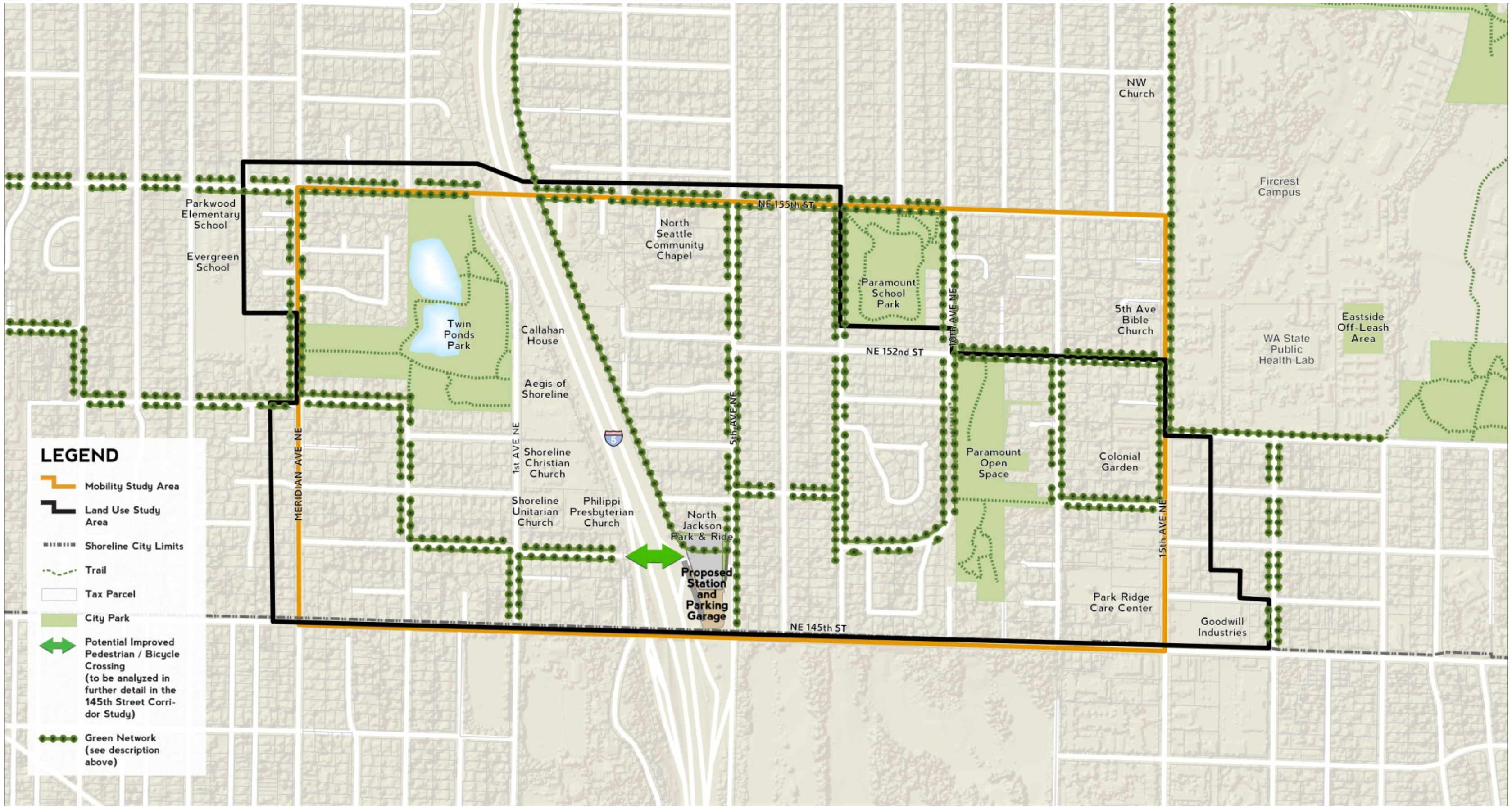


Figure 3.4-12 The Green Network Concept Plan